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37683

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76
77
78
79
80
82
83
85
86
87
89
90
91
92
93
96
95
97
99
100
101
102
104
74
75
73
72
81
71
84
70
69
68
88
67
65
64
63
62
94
61
98
60
59
57
56
54
52
51
32
33
34
36
37
38
103
40
66
45
58
55
53
50
48
49
30
28
36
41
42
43
44
46
31
29
27
25
39
21
20
47
18
17
16
15
2
26
24
23
22
19
14
13
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5
6
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10
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FOR THE

Promotion of Engineering Education

PROCEEDINGS

OF THE

TWENTY-FOURTH ANNUAL MEETING

HELD AT

UNIVERSITY OF VIRGINIA, UNIVERSITY, VA.
JUNE 19-22, 1916

VOLUME XXIV

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PITTSBURGH, PA.
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1916

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TABLE OF CONTENTS.

Frontispiece ... i
Key to Convention Picture ... ii
List of Officers ... v
Members of the Council ... v
Committees of the Society ... vii
Past Officers ... x
Members of Previous Councils ... xi
Deceased Members ... xiv
Program of the Twenty-Fourth Annual Meeting ... xvi
Minutes of the Twenty-Fourth Annual Meeting ... 1
  Minutes of Council Meetings ... 8
  Minutes of Institutional Delegates' Meeting ... 11
  Treasurer's Report ... 12
  Secretary's Report ... 14
Address of Welcome on Behalf of the University of Virginia.—**Edwin A. Alderman** ... 18
Address of Welcome.—**William M. Thornton** ... 20
Response.—**Henry S. Jacoby** ... 26
Some Details in Engineering Education.—**Henry S. Jacoby** ... 27
Report of Committee No. 4, Committee on Committees ... 43
Report of Committee No. 5, Joint Committee on Engineering Education ... 45
Report of Progress in the Study of Engineering Education.—**C. R. Mann** ... 48
  Discussion ... 67
Report of Committee No. 6, Classification of Colleges ... 98
Report of Committee No. 7, Institutional ... 99
  Discussion ... 101
Report of Committee No. 8, Entrance Requirements ... 103
  Discussion ... 122
Report of Committee No. 9, Administration ... 126
  Discussion ... 132
Report of Committee No. 10, Mathematics ... 143
  Discussion ... 149
Report of Committee No. 11, Physics ... 159
  Discussion ... 171
Report of Committee No. 12, English ... 177
  Discussion ... 183

37683

REPORT OF COMMITTEE NO. 13, MECHANICS AND HYDRAULICS 194
Discussion 195
REPORT OF COMMITTEE NO. 14, ECONOMICS 198
REPORT ON CIVIL ENGINEERING 200
Discussion 208
REPORT OF COMMITTEE NO. 16, MECHANICAL ENGINEERING 210
Discussion 215
REPORT OF COMMITTEE NO. 17, ELECTRICAL ENGINEERING 221
Discussion 224
REPORT OF COMMITTEE NO. 18, MINING ENGINEERING 229
REPORT OF COMMITTEE NO. 19, STATISTICS 231
REPORT OF COMMITTEE NO. 20, TECHNICAL NOMENCLATURE 241
Discussion 268
RESEARCH AS AN ELEMENT OF THE GROWTH AND PROGRESS OF THE SCHOOL.—P. F. Walker 284
Discussion 290
OCCUPATION AND DISTRIBUTION OF GRADUATES FROM ENGINEERING COLLEGES.—A. A. Potter and M. R. Bowerman 304
A PLEA FOR THE FURTHER STUDY OF EFFICIENT METHODS IN THE ADMINISTRATION OF AN ENGINEERING COLLEGE.—C. C. Morris 311
ENGINEERING EDUCATION AND COÖPERATION AMONG ENGINEERS.—John F. Hayford 316
THE MEANING OF INTEGRATION IN CALCULUS.—James E. Boyd 319
SOME THOUGHTS ON ENGINEERING EDUCATION.—A. B. McDaniel ... 328
THE HUMAN SIDE OF ENGINEERING.—F. H. Newell 333
Discussion 335
OBITUARIES 337

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To make a study of catalog descriptions of courses of study.

8. **Committee on Admission:** E. F. Coddington, **Chairman,** H. L. Kent and H. E. Webb.

Study of the methods of admission to engineering schools including European schools.

9. **Committee on Administration:** W. M. Thornton, **Chairman,** F. H. Constant, C. H. Benjamin, W. M. Riggs, R. W. Gay, O. V. P. Stout and A. H. Fuller.

Occupation of engineering teachers during the summer vacation.

(1) Present status of summer employment.

(2) Opportunities for such employment.

(3) Fields recommended.

10. **Mathematics:** L. C. Plant, **Chairman,** E. J. Berg, E. R. Hedrick, H. E. Cobb and C. S. Slichter.

To what extent does coördination exist between mathematics, physics and mechanics?

11-A. **Committee on Physics:** G. W. Stewart, **Chairman,** F. K. Richtmyer, Barry MacNutt, C. F. Burgess and H. H. Higbie.

Study of the first course in Physics.

11-B. **Committee on Chemistry:** R. M. Bird, **Chairman,** J. H. James and J. R. Withrow.

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Continue the work as outlined for the previous year and try to complete the report.

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William A. Anthony	1907	May 29, 1908.	XVI, 409
George W. Atherton	1904	July 24, 1906.	XIV, 292
Warren Babcock	1908	May, 1913.	XXI, 434
Volney G. Barbour	1894	June 4, 1901.	IX, 340
Charles B. Brush	1893	June 3, 1897.	VII, 181
Storm Bull	1893	November 18, 1907.	XVI, 407
Octave Chanute	1907	November 23, 1910.	XIX, 501
S. B. Charters, Jr.	1911	December 29, 1912.	XX, Part II, 493
S. B. Christy	1893	Nov. 30, 1914.	XXII, 415
Eckley B. Coxe	1894	May 13, 1895.	VII, 182
Chas. S. Denison	1893	July 31, 1913.	XXII, 411
Dickinson, W. P.	1909	Nov. 4, 1915.	
A. J. DuBois	1894	Oct. 19, 1915.	
Thomas M. Drown	1895	November 16, 1904.	XII, 244
Chas. B. Dudley	1894	December 21, 1909.	XVIII, 446
Francis R. Fava, Jr.	1894	March 28, 1896.	VII, 183
A. J. Frith	1911	November 10, 1913.	XXI, 435
Estevan A. Fuertes	1894	January 16, 1903.	XI, 372
Henry Fulton	1894	December 6, 1901.	X, 258
John Galbraith	1893	July 22, 1914.	XXII, 410
Thomas Gray	1895	December 19, 1908.	XVII, 238
Wm. F. Gurley	1913	February 17, 1915.	XXII, 417
Herbert G. Greer	1894	March 7, 1900.	VIII, 371
Lyman Hall	1904	August 16, 1905.	XIV, 287
E. L. Hancock	1903	October 1, 1911.	XIX, 505
Albert H. Heller	1903	February 20, 1906.	XIV, 290
H. R. Huelle	1914		
John B. Johnson	1893	June 23, 1902.	X, 259
J. W. Johnson	1907	August 29, 1911.	XIX, 506
Rodney G. Kimball	1894	April 25, 1900.	X, 261
Burton S. Lanphear	1897	October 14, 1904.	XII, 249
Benjamin F. La Rue	1899	December 22, 1903.	XII, 243
N. W. Lord	1907	May 23, 1911.	XIX, 507
C. S. Magowan	1896	November 14, 1907.	XVI, 406
F. O. Marvin	1893	Feb. 11, 1915.	XXII, 416
A. G. Smith	1909	Nov. 5, 1916.	

NAME.	YEAR OF ELECTION	DATE OF DEATH.	MEMOIR. Vol. Page.
K. E. GUTHE	1914		XXIV,
LOUIS DUNCAN	1904	February 13, 1916.	XXIV,
A. E. HAYNES	1895	March 12, 1915.	XXIV,
J. W. MULDOWNEY	1912	Sept. 15, 1916.	XXIV,
F. H. ROBINSON	1894	October, 1916.	XXIV,
G. D. WALTERS	1913	January 15, 1916.	XXIV,
A. G. SMITH	1909	Nov. 5, 1916.	
A. C. EINSTEIN	1911	1916.	
ELMER CORTHELL	1895	1916.	
H. A. SAYRE	1910	1916.	

FINAL PROGRAM OF THE TWENTY-FOURTH ANNUAL MEETING, UNIVERSITY OF VIRGINIA, UNIVERSITY, VA., JUNE 19–22, 1916

Monday, June 19.

9:30 A. M.—Meeting of Committee on Committees.

10:00 A. M.—Council Meeting.

11:00 A. M.—Meeting of Institutional Delegates,

Vice-President G. R. Chatburn, presiding.

2:00 P. M.—Opening Session.

President Henry S. Jacoby presiding.

Address of Welcome. Edwin A. Alderman, President, Univ. of Virginia.

Response. President Henry S. Jacoby.

Report of Treasurer.

Appointment of Auditing Committee.

Report of Secretary.

Appointment of Committees on Resolutions and Nominations.

Report of Committee No. 4, Committee on Committees. H. S. Jacoby, *Chairman,* Cornell University.

Report of Committee No. 7, Institutional Committee, G. R. Chatburn, *Chairman,* University of Nebraska.

Report of Committee No. 5, Joint Committee on Engineering Education. Desmond FitzGerald, *Chairman,* Brookline, Mass.

Address. Report of Progress on the Study of Engineering Education, Dr. C. R. Mann, Carnegie Foundation for the Advancement of Teaching.

Report of Committee No. 6, Joint Committee on Classification of Colleges, C. S. Howe, President, Case School of Applied Science.

5:00–6:30 P. M.—Reception. The Colonnade Club.

8:00 P. M.—Annual Society Smoker.

TUESDAY, JUNE 20.

9:00 A. M.—Meeting of Council.

9:30 A. M.—Second Business Session,

President Jacoby presiding.

Report of Committee No. 8, Entrance Requirements for Engineering Schools, J. J. Flather, *Chairman*, University of Minnesota.

Discussion: J. S. Grasty, Harrison Webb.

Report of Committee No. 9, Administration, F. H. Constant, *Chairman,* Princeton University.

Discussion: C. Derleth, Jr., A. H. Fuller, D. C. Jackson, F. E. Turneaure, W. M. Thornton.

Paper—Student and Faculty Activities in a City Technical School, by Hollis Godfrey, President, Drexel Institute.

Paper—A Plea for the Further Study of Efficient Methods in the Administration of an Engineering College, by C. C. Morris, Assistant to the Dean, The Ohio State University.

Report of Committee No. 19, Committee on Statistics, A. J. Wood, *Chairman*, The Pennsylvania State College.

Discussion: L. G. Hoxton, H. B. Shattuck.

Report of Committee No. 20, Committee on the Standardization of Technical Nomenclature, J. T. Faig, *Chairman,* Univ. of Cincinnati.

Discussion: Jas. Aston, C. H. Benjamin, Wm. Kent, J. S. Lapham, C. W. Park.

Paper—Graduate Courses for Practicing Engineers, by A. H. Blanchard, Professor of Highway Engineering, Columbia University.

1:00 P. M.—Luncheon to Visiting Ladies.

The Blue Ridge Club.

Tuesday afternoon has been set aside for a trip to Monticello, the home of Jefferson.

Wednesday, June 21.

9:00 A. M.—Meeting of Council.

9:30 A. M.—Third Business Session.

President Jacoby presiding.

Report of Committee on Nominations.

Election of Officers.

Report of Committee No. 10. Mathematics. L. C. Plant, *Chairman*, Michigan Agricultural College.

Discussion: E. R. Maurer, D. C. Miller. W. M. Thornton, E. H. Wood.

Paper—The Meaning of Integration in Calculus, by James E. Boyd, Professor of Mechanics, The Ohio State University.

Report of Committee No. 11. Physical Sciences, D. C. Miller, Chairman, Case School of Applied Science.

Discussion: R. M. Bird, H. S. Hower.

Paper—Teaching Chemistry at the University of Virginia, by R. M. Bird, Professor of Chemistry, University of Virginia.

Report of Committee No. 13. Mechanics and Hydraulics, E. R. Maurer, *Chairman*, University of Wisconsin.

Discussion: J. E. Boyd, G. R. Chatburn, C. M. Sparrow.

1:30—Afternoon Session.

Report of Committee No. 12. English, S. C. Earle, *Chairman*, Tufts College.

Discussion: Hollis Godfrey, Wm. Kent, Wm. T. Magruder, C. W. Park, C. Alphonso Smith.

Report of Committee No. 14, Economics, J. A. L. Waddell, *Chairman*, Kansas City.

Discussion: T. W. Page, W. M. Riggs.

Paper—Occupation and Distribution of Engineering Graduates, by A. A. Potter, Dean, Engineering Division, Kansas State Agricultural College.

Paper—Engineering Education, by A. B. McDaniel, Assistant Professor of Civil Engineering, University of Illinois.

4:00 P. M.—General Meeting.

Conducted by Institutional Delegates.

Paper—Research as an Element of the Growth and Progress of the School,

(a) As an aid to teaching.
(b) As a means to keep instructors in a condition of growth.
(c) For the value of results.
(d) To make possible the efficient and economical use of laboratory equipment.

By P. F. Walker, University of Kansas.

Discussion: C. L. Crandall, C. H. Crouch, C. Derleth, Jr., A. H. Fuller, Hollis Godfrey, D. C. Jackson, C. E. Magnusson, A. A. Potter, W. S. Rodman, F. E. Turneaure, P. F. Walker.

5:00 to 6:30—Reception.

Dean and Mrs. Thornton.

7:30 P. M.—Annual Dinner.

Presidential Address. Professor Henry S. Jacoby
Some Details in Engineering Education.

THURSDAY, JUNE 22.

9:00 A. M.—Meeting of Council.

9:30 A. M.—Fourth Business Session,

President Jacoby presiding.

Report of Committee on Resolutions.

Report of Committee No. 18, Mining Engineering, F. W. Sperr, *Chairman*, Michigan College of Mines.

Discussion: H. B. Meller.

Report of Committee No. 15, Civil Engineering, F. P. McKibben, *Chairman*, Lehigh University.

Discussion: J. C. Tracy, J. L. Newcombe.

Report of Committee No. 16, Mechanical Engineering, A. M. Greene, Jr., *Chairman*, Rensselaer Poly. Inst.

Discussion: B. W. Benedict, F. C. Wagner, A. L. Williston, Chas. Hancock.

Report of Committee No. 17, Electrical Engineering, C. F. Scott, *Chairman,* Sheffield Scientific School.

Discussion: F. C. Caldwell, L. H. Harris, S. R. Pritchard, W. S. Rodman, J. F. Wilson.

12:30 P. M.—Adjournment.

LOCAL COMMITTEES.

General Committee.—Professor W. S. Rodman, *Chairman,* Dean W. M. Thornton, Professor J. L. Newcombe, Mrs. W. S. Rodman, Professor Chas. Hancock, Professor J. S. Lapham.

Housing and Registration Committee.—Professor W. S. Rodman, *Chairman,* Professor J. S. Grasty, Mr. A. W. Wright, Mr. E. J. Oglesby, Mr. N. E. Oglesby, Mr. T. R. Snavely, Mr. John Ridout, Jr.

Entertainment Committee.—Professor J. S. Lapham, *Chairman,* Professor L. G. Hoxton, Mr. P. H. Graham.

Committee on Dining Hall.—Professor J. L. Newcombe, *Chairman,* Professor W. S. Rodman, Professor J. H. Cline.

Excursion Committee.—Dean W. M. Thornton, *Chairman.* Professor J. L. Newcombe, Mr. E. T. Browne.

Program Committee.—Professor Charles Hancock, *Chairman,* Professor R. M. Bird, Mr. E. N. Tucker.

Ladies' Entertainment Committee.—Mrs. W. S. Rodman, *Chairman,* Mrs. T. L. Watson, Mrs. J. S. Grasty, Mrs. C. M. Sparrow.

MINUTES OF THE TWENTY-FOURTH ANNUAL MEETING.

UNIVERSITY, VA.

JUNE 19 TO JUNE 22, 1916.

The twenty-fourth annual meeting of the Society for the Promotion of Engineering Education was held at the University of Virginia, University, Va., June 19 to 22, 1916. The sessions were held in the main assembly room of Madison Hall. Registration headquarters were in the lobby of Madison Hall.

MINUTES OF THE REGULAR SESSIONS.

MONDAY, JUNE 19.

Afternoon Session.

The meeting was called to order at 2:00 P.M. by President Henry S. Jacoby, Professor of Bridge Engineering, Cornell University, who introduced President E. A. Alderman of the University of Virginia. President Alderman introduced W. M. Thornton, Dean of the Department of Engineering, who delivered the address of welcome. President Jacoby responded for the Society.

The reading of the Treasurer's report was, at the request of the Treasurer and in accordance with the usual custom, deferred until following its presentation to the Council.

Library
N. C. State College

The Secretary, Dean F. L. Bishop, presented his report. which upon motion was received. President Jacoby appointed Messrs. A. H. Blanchard, Chairman, H. H. Norris and C. R. Mann as members of the Auditing Committee to audit the books of the Treasurer. This Committee was appointed upon recommendation of the Council.

Professor Jacoby, Chairman of Committee No. 4. Committee on Committees, asked Professor F. H. Constant to read the report of that Committee. This report was read and accepted. Professor G. R. Chatburn, Chairman of Committee No. 7, Institutional Committee, presented the report of his Committee, which was adopted by unanimous vote. Professor W. S. Rodman, on behalf of the Local Committee, made announcements regarding the Colonnade Club Reception; the Annual Society Smoker; the group photograph; luncheon for the ladies at the Blue Ridge Club on Tuesday; the Tuesday afternoon trip to Monticello; the Annual Society Dinner on Wednesday evening; and arrangements for the historic trip following the Convention. Mr. Desmond FitzGerald, Chairman, Committee No. 5, Joint Committee on Engineering Education, presented the report for this Committee. Dr. C. R. Mann then presented a report of progress in the study of engineering education. A discussion of these reports followed. It was moved, seconded and carried that some time be found on the program in order to hear further from Dr. Mann and have a more satisfactory and complete discussion of his report. (Later determined by the Program Committee to include this discussion in special session of Tuesday evening.)

Tuesday, June 20.

Morning Session.

The meeting was called to order at 9:30 with President Jacoby in the chair. The Treasurer, Mr. W. O. Wiley presented his annual report, giving the condition of the treasury as of June 15, 1916, the complete report to be made after June 30. This report was referred to the Auditing Committee. In the absence of the Chairman, Professor J. J. Flather, Mr. C. M. Wirick presented the report of Committee No. 8, Entrance Requirements for Engineering Schools. Professor F. H. Constant, Chairman of Committee No. 9, Administration, presented the report for this Committee. A discussion of these two reports followed. President Hollis Godfrey then presented his paper, "Student and Faculty Activities in a City Technical School," followed by discussion. Professor C. C. Morris being absent, his paper, "A Plea for the Further Study of Efficient Methods in the Administration of an Engineering College," was read by title. Professor J. T. Faig, Chairman of Committee No. 20, Standardization of Technical Nomenclature, presented the report for this Committee. A discussion followed. In the absence of Professor A. H. Blanchard, his paper, "Graduate Courses for Practicing Engineers," was read by title. President Jacoby announced a special meeting for Tuesday evening at 8:00 P.M. to give time for the discussion of Dr. Mann's report; to continue discussion of the subjects not completed in Tuesday morning's session; and to take out of Thursday morning's program enough material to allow the Society to close its last session before 10:00 A.M. The names of the members of the Nominating Committee present were announced at this time as follows: C. L. Crandall, C. S. Howe, A. H. Fuller, A. W. Greene, Jr., D. C. Miller, D. C. Jackson, and W. T. Magruder.

Tuesday Evening.

The special session of the Society was called to order at 8:00 P.M. with President Jacoby in the chair. Professor D. C. Jackson moved that hereafter the Program Committee, before allotting time to any paper on the program, carefully make an assignment of time for presentation of the paper; for those who are requested to discuss the paper, and also time for general discussion. This motion was seconded and carried. The report of the Committee on the Standardization of Technical Nomenclature was then discussed. Motion was made and seconded that the Committee take up the question of nomenclature with the national engineering societies, looking to the appointment of a committee of two members from each of these societies to act as a joint committee on this subject. This motion was amended to refer the matter to the Council with the recommendation of the Society that it be passed. The motion as amended was then carried. The report of Dr. Mann was then discussed.

Wednesday, June 21.

Morning Session.

The meeting was called to order at 9:30 with President Jacoby in the chair. The report of the Institutional Committee was presented and adopted. The Nominating Committee then reported as follows:

For President: G. R. Chatburn, University of Nebraska.

For First Vice-President: Hollis Godfrey, Drexel Institute.

For Second Vice-President: W. M. Thornton, University of Virginia.

For Secretary: F. L. Bishop, University of Pittsburgh.

For Treasurer: W. O. Wiley, 432 Fourth Avenue, New York, N. Y.

For members of the Council to serve for three years: E. J. McCaustland, University of Missouri; F. G. Higbee, State University of Iowa; R. W. Gay, Mississippi A. & M. College; T. E. French, The Ohio State University; A. H. Blanchard, Columbia University; A. A. Potter, Kansas State Agricultural College; Wm. H. Browne, Jr., North Carolina A. & M. College.

On motion the Secretary was instructed to cast the unanimous vote of the Society in favor of all the above candidates. Upon recommendation of the Council, the Society by motion selected Northwestern University, Evanston, Ill., as the meeting place for 1917. The report of Committee No. 19, Statistics, was then presented by the Chairman, Professor A. J. Wood, followed by the report of Committee No. 10, Mathematics, presented by the Chairman, Professor L. C. Plant. These two reports were then discussed. A motion was made, seconded and carried that the Society go on record as advising and urging the formation of conference committees in the various institutions on which there should be representatives from the departments of mathematics, physics and mechanics and such other departments as are interested. A paper, ''The Meaning of Integration in Calculus,'' was read by Professor James E. Boyd. Professor D. C. Miller, Chairman of Committee No. 11, Physical Science, presented the report for this Committee. Discussion. Professor R. M. Bird read a paper on ''Teaching Chemistry at the University of Virginia.'' Professor E. R. Maurer, Chairman of Committee No. 13, Mechanics and Hydraulics, presented the report for this Committee. A motion was made, seconded and carried that the Committee on Mechanics and Hydraulics in the preparation of the syllabus hold conferences either by letter or otherwise with the Committee on Physics.

Afternoon Session.

The afternoon session was called to order at 1:30 P.M. with President Jacoby in the chair. The report of Committee No. 14, Economics, was presented by the Chairman, Dr. J. A. L. Waddell. Dean A. A. Potter read a paper, ''Occupation and Distribution of Engineering Graduates.'' Professor F. H. Newell then read his paper on ''The Human Element in Engineering Work.'' A brief discussion followed. In the absence of the Chairman, Professor S. C. Earle, Professor C. W.

Park presented the report of Committee No. 12, English. This report was discussed. Professor A. B. McDaniel read a paper on "Some Thoughts on Engineering Education." In the absence of the members of Committee No. 17, Electrical Engineering, the report of this Committee was not read, it being already in print. At the request of the members of Committee No. 15, Civil Engineering, permission was given to postpone their report until the next meeting. Professor F. W. Sperr, Chairman of Committee No. 18, Mining Engineering, then presented the report of that Committee.

THURSDAY, JUNE 22.

Morning Session.

The final session of the Society was called to order at 8:30 by President Jacoby. Professor A. M. Greene, Jr., Chairman of Committee No. 16, Mechanical Engineering, presented the report of this Committee. In the absence of Professor S. W. Beyer, Chairman of the Committee on Resolutions, Dean Cory presented the following resolutions, which were adopted by the Society:

"The Meeting of the Society for the Promotion of Engineering Education has been made pleasant and profitable by the many courtesies extended by the University officials and local committee, and the Society takes this opportunity to place on record its appreciation. Therefore be it

"*Resolved*, That the thanks of the Society be extended to President Alderman, Dean and Mrs. Thornton, Professor and Mrs. Rodman, and other members of the local committees for the admirable provisions made for the comfort and entertainment of the visiting members and ladies; to the members of the Colonnade Club, who so graciously received us in one of the classic halls of the University; to the University Y. M. C. A. for the use of Madison Hall and its equipment; to the fraternities for generously opening their houses for the use and convenience of the members; to the University authorities for extending the privilege of the University Commons to the visiting members, and for other courtesies to the success of our meetings. Be it further

"*Resolved*, That the thanks of the Society be extended to the Charlottesville Country Club for entertainment and use of its clubhouse, grounds and equipment; to the Blue Ridge Club for providing a luncheon for the visiting ladies; to Mr. Jefferson M. Levy, owner of Monticello, for the courtesy of opening the home of Thomas Jefferson to the inspection of the visiting members and ladies; and to all who have in any way contributed to make our visit to the Old Dominion State delightful, enjoyable and most profitable."

The convention then adjourned *sine die*.

ATTENDANCE AT THE CONVENTION.

One hundred and forty-seven members and guests registered at the convention. The names follow, those of institutional delegates and members representing institutions being indicated by asterisks: *W. H. Adams, E. A. Alderman, *F. E. Ayer, Harry Barker, J. R. Benton, *S. W. Beyer, R. M. Bird, *F. L. Bishop, Mrs. F. L. Bishop, Master Bishop, J. E. Boyd, H. W. Brown, *W. R. Bryans, F. C. Caldwell, *E. F. Chandler, *G. R. Chatburn, Mrs. G. R. Chatburn, E. F. Coddington.* F. H. Constant, Mrs. F. H. Constant, Master Constant, *C. L. Cory, C. L. Crandall, F. T. Dargan, Mrs. F. T. Dargan, Miss Dargan, J. A. Dent, L. P. Dickinson, L. A. Doggett, C. R. Dooley, N. W. Dougherty, F. P. Dunnington, Mrs. F. P. Dunnington, *S. B. Earle, *W. Easby, Jr., C. A. Ellis, Mrs. C. A. Ellis, J. T. Faig, *J. H. Felgar, F. A. Fish, Desmond FitzGerald, H. C. Forrest, F. E. Foss, T. E. French, *A. H. Fuller, R. W. Gay, J. R. Giblyn, H. H. Goddard, *Hollis Godfrey, Mrs. J. S. Grasty, A. M. Greene, Jr., Mrs. A. M. Greene, Jr., Chas. Hancock, L. H. Harris, R. H. Harrison, E. F. Haux, E. R. Hedrick, W. A. Hedrick, *F. G. Higbee, *H. L. Hodgkins, *C. S. Howe, L. G. Hoxton, D. C. Humphreys, H. S. Hodge, D. C. Jackson, *H. S. Jacoby, Mrs. H. S. Jacoby,

C. R. Jones, Mrs. C. R. Jones, C. W. Kent, Wm. Kent, George Ketchum, *M. S. Ketchum, J. S. Lapham, *J. H. Leete, O. M. Leland, L. S. LeTellier, J. M. Luck, *E. J. McCaustland, A. B. McDaniel, A. L. McRae, G. S. Macomber, Mrs. G. S. Macomber, W. T. Magruder, C. R. Mann, *K. G. Matheson, E. R. Maurer, Mrs. E. R. Maurer, Mr. Maurer, D. C. Miller, H. F. Moore, C. C. Morris, J. L. Newcomb, F. H. Newell, E. J. Oglesby, N. E. Oglesby, T. W. Page, C. W. Park, G. H. Pfeif, H. S. Philbrick, L. C. Plant, Mrs. L. C. Plant, *A. A. Potter, L. H. Rittenhouse, Miss Rizy, *E. H. Rockwell, Mrs. E. H. Rockwell, *W. S. Rodman, Mrs. W. S. Rodman, A. L. Rohrer, W. B. Russell, E. C. Schmidt, W. H. Schuerman, Mrs. W. H. Schuermann, H. B. Shattuck, Mrs. H. B. Shattuck, C. A. Smith, Mrs. C. A. Smith, T. R. Snavely, F. P. Spalding, C. M. Sparrow, *D. W. Spence, F. W. Sperr, W. LeConte Stevens, L. B. Taylor, R. G. Thomas, F. F. Thompson, J. S. Thompson, W. M. Thornton, Mrs. W. M. Thornton, *A. A. Titsworth, *J. L. Van Ornum, Mrs. J. L. Van Ornum, T. Van Ornum, J. A. L. Waddell, *P. F. Walker, T. L. Watson, Mrs. T. L. Watson, W. D. Weaver, Willis Whited, W. O. Wiley, A. L. Williston, Mrs. A. L. Williston, *C. M. Wirick, J. R. Withrow, *A. J. Wood, A. W. Wright.

MINUTES OF COUNCIL MEETINGS.

Meetings of the Council were held on June 19, 20 and 21. Members who attended one or more meetings were: F. L. Bishop, G. R. Chatburn, F. H. Constant, C. L. Cory, C. L. Crandall, A. H. Fuller, A. M. Greene, Jr., C. S. Howe, D. C. Jackson, H. S. Jacoby, M. S. Ketchum, W. T. Magruder, F. P. Spalding, P. F. Walker, and W. O. Wiley.

A motion was made by Dean Walker and seconded by Professor Chatburn that the Council recommend to the Society that in making arrangements for meetings, plans be made for three successive meetings; the first only to be final, the others tentative and subject to revision. Motion carried.

The following budget of income and expense for the coming year was reported by the Executive Committee and adopted by the Council:

Estimated Receipts.

From back dues	$1,000.00
From current dues (individual)	4,700.00
From current dues (institutional)	560.00
From advertising	1,000.00
From sale of publications	300.00
Total	$7,560.00

Estimated Expense.

A—1916 Virginia meeting	$ 300.00
B—Proceedings, Vol. XXIV.	1,300.00
C—Bulletin, Vol. VII.	1,850.00
D—Committee expenses	150.00
E—Treasurer's honorarium	300.00
F—Secretary's honorarium	1,000.00
G—Assistant Secretary's honorarium	600.00
H—Clerical assistance	720.00
I—Sundry printing	200.00
J—Postage and expressage	300.00
K—Telephone and telegraph	25.00
L—Office supplies	100.00
Total	$6,845.00

A motion was made by Professor Magruder that the Executive Committee appoint a Membership Committee, whose duties would be to secure new members and to prevent the loss of members by resignations and by non-payment of dues. A motion was made by Dean Bishop and seconded by Professor Greene that the Constitution stand as it now is and that a committee be appointed to draw up rules relating to the operation of the business of the Society as it has developed in the last few years. This motion was carried. It was moved and carried that the title of the BULLETIN should be changed to "Engineering Education" with the addition in small type of the words "Bulletin of the Society for the Promotion of."

Council Letter Ballots Taken During 1915–16.

October 26, 1915.—Frank Aydelotte, Godfrey Engel, N. E. Ensign, W. R. Etherton, F. A. Fetter, R. L. Glass, J. W. Hallock, J. S. Hendry, D. F. McLeod, E. J. Oglesby, L. L. Patterson, H. E. Porter, H. B. Pratt, K. W. Reed, J. R. Sanders, J. B. Scarborough, H. G. Tyler, W. E. Wigley, Junior College, of Crane Technical High School. (19)

November 22, 1915.—R. J. Anderson, A. R. Bailey, G. E. Beggs, C. P. Bliss, J. H. Cannon, D. E. Carpenter, W. R. Chedsey, J. J. Cox, Herman Diederichs, M. T. Fullan, U. S. Hanna, W. A. Hitchcock, D. S. Kimball, G. A. Koerber, H. B. Langille, A. C. Lanier, F. C. Moore, M. W. Moyle, E. W. Pehrson, J. W. Searson, J. C. Penn, W. F. Mallory, L. H. Shattuck, E. T. Browne, John Ridout, G. W. Munro, Lafayette College, Toledo University, University of Colorado. (29)

January 10, 1916.—H. F. Black, F. E. Cooper, E. J. Ducey, Alex. Gray, H. H. Jordan, C. J. Mackenzie, E. S. McCandliss, J. L. Merrill, N. E. Oglesby, C. W. Park, W. E. Stanley, V. D. Tompkins, E. N. Tucker, Colorado School of Mines, University of Vermont. (15)

March 17, 1916.—J. M. Brouen, G. M. Butler, Collier Cobb, M. W. Davidson, A. H. Forman, F. A. Gould, E. F. Grundhoeffer, F. J. Lewis, C. V. Mann, J. L. Murrie, J. C. Parker, E. A. Reid, W. M. Thornton, I. F. Waterman, C. A. Wright. (15)

April 12, 1916.—H. C. Berry, C. A. Ellis, P. H. Graham, R. S. Hale, H. P. Hammond, K. B. McEachnon, H. C. Ray, W. C. H. Slagle, T. R. Snavely, E. I. Staples, E. R. St. John. (11)

May 27, 1916.—J. M. Coahran, F. L. Carmichael, A. P. Folwell, F. E. Johnson, G. T. Little, Dana McComb, C. S. Sale, A. C. Terrill, W. S. Wolfe, Agricultural and Mechanical College of Texas. (10)

MINUTES OF THE MEETINGS OF INSTITUTIONAL DELEGATES.

The first meeting of the Institutional delegates was held Monday morning, June 19, at 11:00 o'clock, with Vice-President Chatburn presiding. The first business taken up was the report of this Committee published in the June, 1916, BULLETIN. In order to bring the question before the Committee, it was moved and seconded that the five recommendations of the Committee as published on page 700 of that BULLETIN be adopted. After discussing these recommendations the motion was carried.

The recommendation of the Committee with regard to the personnel of the Committee was next taken up. Professor Chatburn read the recommendations as it appeared on page 701 of the June, 1916, BULLETIN. It was moved and seconded that this recommendation be adopted. After discussing the merits of the proposed amendments the question was put to the Committee and lost. The personnel of the Committee, therefore, stands as defined by the rule adopted in 1915.

Professor Chatburn then placed before the Committee for discussion the purposes of Institutional Membership. After general discussion it was moved and carried that a sub-committee of three be appointed to take up the question of the purposes of institutional membership and report at a later session of this Committee. The members appointed were Hollis Godfrey, A. A. Potter and J. L. Van Ornum.

The next item considered was the duties of institutional delegates as printed on page 701–702 of the June, 1916, BULLETIN. The first part dealing with duties before the annual meeting was adopted as printed. The second part dealing with duties of delegates during the annual meeting was amended by striking out the words "as an attorney" in the last sentence. The third part dealing with duties of delegates after the annual meeting was then adopted as printed.

President Jacoby moved that the Committee on Committees be requested to assign the question of standardizing college catalogs to the Institutional Committee as a part of its duties for the coming year, to report on it at the next annual meeting. This motion was seconded by Professor Van Ornum and carried.

The general meeting of the Society conducted by the Institutional delegates was held at 4:00 P.M., Wednesday, June 21. Before taking his place as Chairman of the meeting, Professor Chatburn was introduced as President of the Society for the year 1916–17, by President Jacoby. President Chatburn acknowledged this introduction in a few well-chosen words. After Dean P. F. Walker presented his paper "Research as an Element of the Growth and Progress of the School," the meeting was thrown open for discussion.

TREASURER'S REPORT.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

JUNE 16, 1916.

Trading Account.

Dr.

6/16/15 Inventory	$4,047.50	
Cost of publications*	4,472.47	
	8,519.97	
Surplus. All *Proceedings* previous to 1901 (except 31 of each) charged off	825.00	
	7,694.97	
Less inventory of 6/16/16	3,203.10	
Cost of sales		$4,491.87
		$4,491.87

Cr.

Sales of publications:		
To members and non-members	$ 342.06	
1/4 of members' dues	1,431.50	
3/10 of institutional dues	164.25	$1,937.81
Advertising	1,013.00	
Less discount	13.12	999.88
		2,937.69
Balance—Profit and loss account. *Loss*		1,554.18
		$4,491.87

Profit and Loss Account.

Dr.

Balance—Trading Account	$1,554.18	
Ames annual meeting	247.85	
Committee expenses	240.28	
Treasurer honorarium	300.00	
Secretary honorarium	1,000.00	
Assistant Secretary honorarium	600.00	
Secretary clerical expenses†	540.00	
Postage and expressage	256.16	
Telegraph	38.18	
Office supplies	56.63	
Virginia annual meeting	23.75	4,857.03
		$4,857.03

Cr.

Dues, individual	$4,294.50	
Dues, institutional	383.25	
Discount received	23.00	
Interest on deposit	12.60	
Exchange	.87	$4,714.22
Balance—Deficit for year		142.81
		$4,857.03

Balance Sheet.

Assets.

Accounts Receivable:		
Members,		
Back dues	$1,216.26	
Current dues	1,558.26	
Other items	26.14	
Institutional dues	105.00	
Non-members	377.73	
A/R at Pittsburgh	23.68	$3,307.07
Cash		
Life Membership Fund	397.20	
Lincoln Trust Co.	860.67	
Secretary's Office	150.00	1,407.87
Inventory		3,203.10
		$7,918.04

Liabilities and Surplus.

Accounts payable	$2,159.23	
Due members	88.10	
Due non-members	4.70	$2,252.03
Surplus 6/16/15	6,387.60	

Less—Dues of members dropped or resigned and accounts uncollectable	150.98	
	6,236.62	
Less—*Proceedings* charged off	825.00	
	5,411.62	
Less—Deficit for year	142.81	5,268.81
Life membership		397.20
		$7,918.04

Comparative Balance Sheet.

Assets.	1916.	1915.	Increase.	Decrease.
Accounts receivable:				
Bank dues	1,216.26	607.72	608.54	
Current dues	1,663.26	1,389.04	274.22	
Advertising and publications	427.55	279.90	147.65	
Cash:				
Lincoln Trust Co.	860.67	654.64	206.03	
Union Sq. Savings Bank	397.20	383.68	13.52	
Secretary's office	150.00	100.00	50.00	
Inventory of publications	3,203.10	4,047.50		844.40
	7,918,04	7,462.48	1,299.96	844.40
			844.40	
			455.56	

Liabilities and Surplus.	1916.	1915.	Increase.	Decrease.
Accounts payable	2,159.23	643.96	1,515.27	
Due non-members	4.70	3.50	1.20	
Due members	88.10	43.74	44.36	
Surplus	5,268.81	6,387.60		1,118.79
Life membership	397.20	383.68	13.52	
	7,918.04	7,462.48	1,574.35	1,118.79
			1,118.79	
			455.56	

REPORT OF SECRETARY.

I have asked permission of the President and of the Council to talk on the subject of the Secretary's report rather than to prepare a lengthy document. There are certain items pertaining to the work of the Secretary about which the Society should be thoroughly informed.

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* Does not include cost of *Bulletin* for March, April, May and June.

† Does not include Secretary's expenses from May 25, 1916, to June 16, 1916.

To begin with, the membership of the Society grows continuously and almost uniformly. We have added this year 102 names, up to the time of this meeting. There are several yet to be added. We have lost by resignations 36, by death 4, and for other reasons 10, making a net gain in membership for the year of 52. The total membership last week was 1,504.

Most of the resignations have been from members of the teaching profession who have gone into commercial work. This movement has been quite noticeable during the year. Many of these men retain with interest their membership in this Society. Others, with less breadth of view, think that as soon as they resign their teaching positions they have given up their responsibility as teachers and cease to take an interest in an organization of this kind.

This Society has been officially represented and has taken part in the following meetings and activities: The annual meeting of the American Institute of Mining Engineers in San Francisco; The Illuminating Engineering Society in Washington, D. C.; the Pan American Scientific Congress in Washington, D. C.; the inauguration of J. H. McCracken as President of Lafayette College; the Association of Urban Universities at Cincinnati; the American Road Builders Association in Pittsburgh; the Joseph A. Holmes Safety Association in Washington, D. C.; the Society of Technical Secretaries; the League to Enforce Peace, American Branch, at Washington, D. C.; and the Joint Committee on the Classification of Technical Literature. The work of the Society has been singularly recognized by the request of the Secretary of the Navy, Hon. Josephus Daniels, for a committee of five from this Society to investigate the technical work of the Naval Academy at Annapolis.

The Society took up this year the added burden of committee work. This has led to a very great increase in the work of the Secretary's office. During the year we have sent out a total of 4,123 copies of questionnaires. It was necessary for the Secretary personally to select the larger part of the mailing list in each case, because in practically no instance did the chairman of the committee supply the Secretary with the needed mailing list. If any of you have had opportunity to study a college catalog, and to try to find out who is responsible for a certain work in a given institution, you can appreciate the dilemma which confronted the Secretary in many cases. In regard to questionnaires I have just one thing to say; and that is, that the man who is too tired, too lazy, or lacks sufficient interest to answer a questionnaire submitted by a society of this kind is not a proper man to be connected with the work of engineering education.

One of the incidental duties of the Secretary is to edit the monthly BULLETIN. We have this year edited 806 pages, not including the advertising material, which often needs considerable editing. The June BULLETIN contains 133 pages. A large part of it we hope will appear in next year's *Proceedings.* The Publication Committee, which is responsible for the BULLETIN, must reduce the size of the BULLETIN next year. This has necessitated even this year the rejection of a number of papers which were excellent. It is a different problem to select the papers which will be of the most benefit and which will interest the greatest number of men connected with the Society.

In the year-book for the present year, we made certain changes in the geographical and occupational distribution of the membership, in order that we might reduce eventually the cost of the publication of that number. It now costs about twice as much as any other number of the BULLETIN. I think that with one more change which ought to be made it can be reduced by about one hundred dollars in cost.

The Secretary was very glad to have the *Proceedings* ready for publication and out of the Secretary's hands in November, although it was not placed in the mail until somewhat later. There is no reason, so far as the Secretary can see, why the *Proceedings* should not be published as early as November, and possibly as early as October. It requires the hearty coöperation of those men who take part in this meeting.

To go back to the BULLETIN: the title of the BULLETIN is "The Bulletin of the Society for the Promotion of Engineering Education." This is somewhat lengthy. Men who conserve their time can hardly stop to give it the full title. It is too long to be put on billheads; and libraries always, or practically always, address matter to Engineering Education. This caused the Publication Committee to change the title on the outside cover during the last three months of the year, printing only the words "Engineering Education." We wanted to find out what the members of the Society thought about it. The development of the BULLETIN, or of a magazine devoted to engineering education, is in my opinion one of the most important duties which lies before this Society.

The Secretary's office has a few other duties which might interest the Society. For instance, we distributed 1,175 communications to libraries, in reference to *Proceedings* and other publications of the Society. In return, we received $328.66, being, I think, about three times the cost of sending out these communications. We carried on a campaign for membership which resulted in approximately one hundred new members. Now, I think the Secretary should be assisted by a Membership Committee. You know, no matter how good a man is, or how good a group of men may be, eventually they exhaust all of their originality pertaining to one subject; and how to secure new members is something that exhausts a man in a very short time. I believe a Membership Committee would do excellent work in that respect.

The Secretary attempts to keep the members, especially the Council, informed of all the work which is being carried on. It is, I think, advisable that more communications of various kinds be sent to the members; and that more members send communications to the Secretary.

ADDRESS OF WELCOME.

BY E. A. ALDERMAN,

President of the University of Virginia.

Mr. Chairman, Ladies and Gentlemen of the Society for the Promotion of Engineering Education:

As President of the University of Virginia, I very heartily and cordially welcome you to everything the university has to offer in the way of interest, historic, educational, social, spiritual. Everything we have is yours during your stay here.

I am very proud and very happy to have this party of men meet here—the first time, I am informed, it has ever met south of the historic line. There is a certain fitness that it should have its first meeting south of that line just here, I think. One reason which occurs to me was brought to my mind this morning by a very charming letter I had from the head of the Massachusetts Institute of Technology, reminding me of what I already knew, that this university was the foster-mother of that great school of engineering—through William Barton Robers, who went from our chair of physics to establish that school. So we have created engineering schools elsewhere.

A second reason is that of all the states of the South, perhaps it is true—and I am not merely boasting in saying this—that the State of Virginia received the impact of the most destructive sort of influences that followed the Civil War, in the nature of industrial and social paralysis; and that it has in the last fifty years exhibited a remarkable resilience and power of recuperation. It has transformed itself, as has the whole South, from a rather picturesque, medieval agriculturalism into a modern, democratic industrialism. And much of that work has been the work of the engineer.

I am not an engineer; but I have a peculiar and profound respect for him and for his profession. Somehow it is possible for me to conceive of a schoolmaster as being a muddle-headed schoolmaster. I have seen some of them. There are even muddled-headed preachers; though I hope there are none here to hear me, because they can always reply to you six feet above the possibility of a rejoinder. There may be muddle-headed members of other professions; but somehow I cannot conceive of an engineer who is not a straight-thinking man. The profession and the man seems to me to combine ideally. The engineer must possess himself of the ultimate facts of the great basic sciences which men have developed in this world; and that process takes truth-seeking and truth-finding. Secondly, he must adjust the facts so found, and relate them to the great problems of civilization, as it goes forward. So the engineer to me is not only a seeker after truth, but rather of human order and society.

Now, I am not going to welcome you. I am going to ask another man to welcome you. I did not want this occasion to go by without the very high privilege of personally assuring you of my happiness in your presence here. But I do want you to be welcomed more intimately by the man who a generation ago had the clearness of vision, the steadfastness of purpose, to decide that there should be a real school of engineering at this University, and who for a long time, with utterly inadequate equipment, by the strength of unusual ability bore upon his broad shoulders, without any aid, the problem of keeping hope in the body of the School of Engineering at the University of Virginia. And if I have had any one single pleasure greater than another in my term of service at this University, it has been in the direction of lending every ounce of aid I could to him in the task that he has so handsomely and far-sightedly borne, of building for us our School of Engineering. I take pleasure in introducing to you the dean of the Department of Engineering at this University, William Mynn Thornton.

ADDRESS OF WELCOME.

BY W. M. THORNTON,

Dean of Engineering, University of Virginia.

Mr. President, Members of the Society for the Promotion of Engineering Education, Ladies and Gentlemen:

The gracious words of welcome spoken by President Alderman require no reinforcement. We Virginians are glad to see you in Virginia. Words piled on words could say no more.

Our special and peculiar desire for those who come to this old commonwealth and to its chief seat of learning is this—that they should learn to know its spirit. To those who know it there is a certain winning charm even in its outward aspect. The very genius of the place seems to bid them welcome. The setting of our University amidst the blue Virginia hills utters its salutation. The architecture of its buildings—simple, quaint, beautiful, almost noble—speaks in cordial tones to men and women who love the quiet air of serene studies. And the home of our father and founder, looking down from its hilltop on the work of his hands, still opens its gates with benignant hospitality to neighbors and strangers alike as though the Sage of Monticello dwelt today amidst the scenes endeared to him by all the tender ties of memory and love of faith.

Several years ago my wife received a letter from a correspondent in England commending to her care a very charming and cultured German lady, who came to America to be governess of the children in a wealthy Pennsylvanian family. We invited the fraulein to visit us, and after breakfast on the morning following her arrival I stood with her on the lawn in front of my house and pointed out to her the then visible height of Monticello. "That," I said, "is Thomas Jefferson's home." For a moment she hesitated, then risked the question "Does he live there still?'' This question from the would-be governess of young Americans. I had to explain, of course, that the Jefferson of whom I spoke had long been dead, and that only his ashes consecrated the Mecca of American Democracy. But I have often felt that her naïve question might have deserved another reply and that in a very high and true sense, Thomas Jefferson lives here still.

Some one has quoted of this university the pregnant phrase of Emerson, ''An institution is the lengthened shadow of a man.'' You will find Thomas Jefferson's shadow projected all across the ninety years of its active history and stretching forth into its future. Most versatile of all our publicists—farmer, architect, engineer, naturalist, lawyer, statesman, diplomatist, politician—he was also a profound student of education. His reflections on this theme led him to certain conclusions so novel that for his time they would have been thought revolutionary. Too wise to embody them in a constitution or a code, he went more cannily to work.

Believing in *student self-government,* he erected a group of buildings over which effectual espionage was impossible. It became necessary to trust the students. Self-government under our so-called Honor System was the inevitable outcome.

Believing in the *free election of studies* he subdivided the field of scholarship into great province with natural boundary lines (as law, medicine, ancient languages, natural philosophy). Over each he placed one head professor, who selected his own aides. The student was free to enter any one of these so-called Schools. Thereafter his work was directed by the professor of the school.

Believing in a relation between professor and pupil, founded not on fear but on mutual confidences and respect, he took away from his faculty all police power, made their disciplinary functions purely monitory, and thus rendered inevitable *faculty government by influence* and not by authority.

In the main, barring the natural infirmities of academic foolishness, these ideas prevail in Virginia today. Thomas Jefferson lives here still.

In the ninety years which has intervened since July 4, 1826, these educational axioms have become in large measure the common property of American universities. Ninety years ago they were the ideas of a revolutionist and even in Jefferson's native state were anathema maranatha to many sincere souls. Many decades passed before Brown first and then Harvard borrowed from us the elective system, exploited it as a discovery of their own, and transformed it into that elective chaos with which we are all familiar. Many more decades were to pass before Princeton under the urgency of one of our own alumni, Professor Woodrow Wilson, borrowed from us in a mitigated form, the Honor System and patiently suffered the newspaper reporters to give it enviable publicity as the Princeton System. Today we await the happy hour when some other great American university will borrow from us the conception of the government of students by influence and show us how it really ought to be worked.

It is not simply as a great educational reformer that we would have you regard Thomas Jefferson. We desire you rather to think of him on more human sides, as we Virginians find ourselves thinking of him.

As the son of a Virginian farmer, old Peter Jefferson of Shadwell, growing up on his father's plantation, riding after the hounds, hunting birds and wild turkeys, studying Latin and Greek with the Episcopal parson of his parish church—a country boy keen about all the wholesome sports of country life.

As a young collegian at William and Mary, where he learned to love scientific studies even better than the humanities; yet finding time for his violin for musical evenings in the drawing room of the Colonial Governor Fauquier and for stimulating converse of the colonial statesmen who gathered around Fauquier's hospitable mahogany; finding also time and money to keep a race horse or two, and to enter them on the Williamsburg tracks.

As a young lawyer, trained in the offices of the greatest of the Virginian jurists, Chancellor Wythe; giving five earnest years to the energetic study of his chosen profession; and then stepping straight into one of the most lucrative practices in the Virginia courts.

As a lover, wooing the beautiful widow who afterwards became his wife with the music of his violin as well as with the soft sophistries of his nimble tongue; as a father adored equally by his enamoured spouse and his devoted children; as a brother of rarest loyalty and tenderness and fidelity; as a friend with whom the bond of friendship stretched far beyond the chill oblivion of the grave.

As a home builder, who reared on the hilltop chosen in his early manhood, that lovely model of our colonial architecture which even in this day of domestic palaces makes to every eye its intimate and unforgetable appeal.

In my early days at this school I met an old gentleman who, as a lad, had known Jefferson, then nearing eighty years, and had often watched the old man's still erect and supple figure as he rode by on his way from Monticello to scan the rising walls of his infant university. I remember still the thrill I felt when my old friend spoke of ''Mister Jefferson.'' It is thus that we Virginians love to think of him. It is thus that we should love you to think of him. As the kind neighbor and the tender husband and the devoted father and the loyal friend; rather than as the dauntless patriot, the far-seeing statesman, the matchless party-leader, the most powerful of American presidents. Thomas Jefferson had a genius for statecraft, a genius for politics, a genius for architecture; but above all these I rank his genius for friendship and his genius for domestic love. The one has seemed to me the secret of his primacy in public affairs; and when you visit his home perhaps you will find in the other the secret of the abiding charm of Monticello.

One point as to Jefferson's plans of university organization may be of special interest to this audience. There was a ninth school which he wished to incorporate into his plan of eight—a school parallel with those of law and medicine—what he called the School of Civil Architecture. The name was chosen to distinguish it from what he would have called military engineering. Our present School of Engineering, established only after many years, fills the gap left empty because of Jefferson's narrow means. It was not unnatural for us to treat this as a purely professional school just as we had treated law, just as we had treated medicine, and to make no provision in it for the so-called humanities. Many of our friends have brought in question the wisdom of our plan; have doubted whether we were wise in this to follow Jefferson.

It would be too long here to argue the case. I have to confess that we are in a small minority. The great mass of the American schools of engineering have decided against our plan. Yet when I read the searching criticisms of the professional journals on the failure of the majority plan; the caustic comments of the leaders of our profession on the illiteracy of engineers; the earnest admonitions addressed to our colleges on the inadequacy of their engineering graduates either to write with clearness or to speak with force, my confidence in the wisdom of the majority plan is rudely shaken. I look then to our law school in which the students are trained in oral discussion of legal problems, in preparation of written briefs, and in the technique of public speaking; whose graduates easily and swiftly press forward to the front ranks of the legal profession and to the high seats of political life; and I ask myself whether legal studies have higher cultural value than scientific studies. I look to the graduates of our own medical school, find the story of their training here and their success abroad equally inspiriting, and ask myself whether medical studies excel in cultural value the studies of the young engineer. The only answer I have so far found myself able to give is NO. If the graduates of our engineering schools are

Library
N. C. State College

justly charged with impotence of tongue or pen, the cause must be laid at the door of the professors of engineering, not at the door of the topics of instruction.

There is, I am persuaded as much cultural value in a carefully studied and conscientiously prepared report on an engineering project as in any legal brief or medical essay. The very history of engineering is full of romance, full of interest, full of inspiration. We who present our topics so languidly, so aridly, so nakedly are at fault. Let us use our own materials adequately and we shall not need those weak broths of English literature, those tenuous emulsions of political history, those dry-as-dust post toasties of economics, which are dished out to young engineers as fruits from the tree of life. Until I see better results from the conventional methods I shall doubt the nutritive value of these breakfast foods of the technological banquet.

And now a brief word of apology. If you overhear one of our people talking to himself and saying that here was founded the first true American university; or that the honor system and the elective system and student self-government originated here; you must forgive him, even if you do not agree with him. For there are lots of us old Virginians who believe that a certain wise man named Thomas Jefferson, once lived here and that he still lives here. I hear him now; as I read the morning *Telegram* the echo of his voice comes back to me:

"Peace is our passion; wrongs might drive us from it; but we prefer trying every other just principle before we would recur to war."

I see him now looking with grave prophetic eyes into the future; full of a noble and tender faith that error had no real chance against truth, provided truth and freedom were allied to combat it; full of a reverent trust that the great power that had guarded his people in the past would guide and uphold them forever.

RESPONSE ON BEHALF OF THE SOCIETY.

BY HENRY S. JACOBY,

President of the Society.

President Alderman and Dean Thornton: It is a genuine pleasure, in behalf of the Society, to respond to the cordial and generous welcome which you have just extended to us. We were glad to receive your invitation and to accept it; to come to the Southland and to the Old Dominion state with its rich historic associations, and which has given birth to so many noble patriots, statesmen, and scholars. We rejoice to be the guests of the University of Virginia, whose honorable history, scholarly achievement, and lofty spirit of honor have had such a beneficent influence. It will be a delight to go about your campus, where classic architecture is such a dominant feature, and where the fragrant memory of its unique Founder abides. It is gratifying to note that, in response to modern needs and the growing spirit of service to the state, the School of Engineering was added, and that it is housed in close proximity to the halls where ancient languages and the humanities are taught.

Our Society is completing the twenty-third year of its life. Its proceedings and bulletins now occupy a little over five feet on a book-shelf. In modifying its methods of activity by a reorganization and extension of systematic committee work, the Society hopes to renew its youth and to bear aloft an ideal of more helpful service to its members and to the engineering colleges of our country.

We believed that we would be welcome guests; now we know it. I am sure that all the visiting members of the Society will deeply appreciate your kind hospitality. We thank you most sincerely.

SOME DETAILS IN ENGINEERING EDUCATION.

Presidential Address.

HENRY S. JACOBY,
Professor of Bridge Engineering, Cornell University.
President of the Society for the Promotion of Engineering Education.

One of the duties of the President of the Society, according to custom, is to deliver an address at the annual meeting upon some subject relating to engineering education. In trying to decide upon the topics to be considered upon this occasion, it was recalled that progress in engineering in recent years has been due in considerable measure to greater attention to details. Details which are now designed with the same care as the main members of a structure or machine, were formerly regarded as unworthy of serious study.

It has been possible to construct derricks, for example, of much larger capacity, by designing the connections of members so as to eliminate bending stresses due to eccentricity. Economy both in first cost and maintenance as well as safety were thus secured by substituting direct tension or compression for flexural stresses. A generation ago, bridges were erected by experienced cȏntractors who carried on their work mainly by exercising their judgment, and strengthening the falsework in parts which were observed to be weak in previous cases. This method of construction by trial proved unequal to the demands of modern progress, accidents became more frequent, and the foremost erecting contractors lost their lives.

The plan was next adopted of designing the falsework, as well as the erecting appliances and methods, in advance of erection, with the same care which is applied to the design of the bridge superstructure itself. By thus laying out a complete plan of procedure and designing every detail of structure or equipment, it is possible today to erect structures of enormous magnitude in a satisfactory manner. By designing is meant the application of the laws of mechanics and of other sciences to determining the form and proportion of every part, in addition to selecting the kind of material to be used.

Progress in engineering education depends upon the science and art of teaching, and it may be profitable to consider the more thorough application of this science to some details of the teaching process. It is hoped that the treatment of these topics may prove to be of especial value to the younger teachers in engineering colleges.

Diagrams are an important aid in teaching by appealing to the mind through the eye. The relations between given data, or the variations of quantities under changing conditions may thus be grasped in a more comprehensive manner. A diagrammatic representation often simplifies what otherwise appears to be complicated. The value of graphic methods is now so generally recognized that a large volume has recently been published for those who are engaged in commercial or industrial pursuits.

Diagrams may become so familiar to the teacher that he takes for granted that the student comprehends their full significance. A failure to test this matter involves real loss to the student. It is a most valuable exercise to require him to express in words the relations which are indicated by the diagram. It is not always sufficient that he understand the mode of its construction.

Since diagrams are increasingly employed in designing in place of formulas with several variable factors dependent upon one another, it is desirable that the student should learn how to use them. The object is not primarily to acquire skill in their use, but to study the relative influence of the different factors upon the result, and what degrees of precision are required.

Mathematical equations also express relations in a very compact form. And herein lies a real difficulty to the student, which often leads to lack of clearness, definiteness, and reality. Is it not true that the reason why students sometimes misinterpret and misapply formulas or equations is that they have not been required to express in words the meaning of such equations, or the laws expressed by them, just as accurately as ordinary human language permits? Would not this practice, if adopted, contribute immensely to clear thinking, and perhaps help to make his mathematics a more available and useful tool?

Engineering teachers recognize the value of problems in teaching most of the courses as never before, and hence their use is steadily increasing. Problems are used not only in the class room but are assigned for solution outside and returned in the form of reports. Problems are valuable for other reasons than to show how a given principle or law may be applied. The solution of different problems involving the same principle will not only show the scope of its application, provided the problems are wisely selected, but will often afford additional light on the nature of the principle itself. In no other way can the fundamentals of engineering science be so firmly fixed in mind.

In view of the important function of the solution of problems, especial care and ample time should be taken in their preparation. As far as possible, they should be practical in character, thus enlisting the personal interest of the student, and incidentally making him familiar with the magnitude of loads, dimensions, forces, velocities, etc., which are in current use in professional practice relating to the subject being studied. The proper selection of problems calls for experience and good judgment, and hence the responsible heads of departments should recognize this task as worthy of their best efforts, and not delegate it wholly to young instructors. If problems for a given course of instruction do not form a part of the equipment of a department it naturally follows that the students will suffer through less effective class work while a new and inexperienced instructor develops his own set of problems. How long would it take for a new teacher with the rank of instructor to prepare, for example, a set of problems in mechanics or hydraulics, or bridge stresses that is worthy of the name?

When used in connection with recitations, especial caution should be exercised that each problem is so limited in its scope that it can be solved ordinarily during the half-hour or more which is available for the purpose. A long problem for which time permits only a partial solution tends to discourage the student, rather than to help him. A group of typical problems which practically cover the lesson for the day may be so arranged at the blackboard that the recitations will be sure to include them even if some of the other problems which are similar but have different data may not be reached within the period.

The test of experience will show which problems are worthy of being retained in use for some years, and which ones need early revision or replacement. While minor revisions may be made annually, it is more likely that a course will be kept up to date if more radical revisions, by substituting many new problems, be made at longer intervals, each course in a department receiving thorough treatment in turn.

The advantage of preparing problems in advance, with painstaking care in selecting and framing them, has an interesting counterpart in the practice of reinforced-concrete building construction. An experienced engineer-contractor said that some years ago, when the foreman and carpenters used to plan the timber forms during actual construction, the forms for columns used to cost eighteen cents per square foot, and the forms for floors twelve cents. At present, much time is spent in the office in making detailed plans before construction is commenced. These plans may cost two tenths of a cent per square foot of form work. Now if the cost of labor for forms runs over one third of what it used to be, an investigation is in order to know the reason why the cost is so high. The teacher's work is not expressed directly in dollars, but saving time and getting better results for the student have a real money value.

If teaching is to be efficient, the element of time deserves especial consideration. Much time can be saved if all problems are written on cards, thus avoiding the necessity for oral instructions. If the first work of the period is at the blackboard, it will encourage promptness, if a definite time limit is set for the recitations to follow. To save time during recitations means must be adopted by which errors are quickly detected, that especial attention may be given to the essential part of a problem which the student fails to understand. This can be accomplished by data suitably arranged in the hands of the teacher. A good instructor desires to be of the largest service to as many members of the class as possible during the limited period available. Other things being equal, it may be laid down as a general principle that the extent and value of his service is directly proportional to the time and effort expended in advance of the lesson period.

In class exercises conducted by questioning where students are expected to state facts or principles, describe methods, structures, equipment, or construction, etc., written questions on cards are found by experience to save considerable time, secure better responses, and maintain greater interest on the part of both students and instructor. The teacher can take more time to frame the questions, making them clear, definite, and properly limited in scope. Oral questions are not entirely eliminated, but they become secondary in importance, and leave the instructor usually free from the handicap of referring to a text-book in class. The art of questioning is essential to good teaching and deserves most careful study and practice.

Another method of saving time is to print lesson assignments and any other directions that may be required to cover the work of the course and thus reduce oral directions to a minimum during class exercises of all kinds. The absentee cannot plead ignorance of the work which is to follow the date of his absence. To conserve the time of both student and teacher for the real purpose of teaching is demanded by good business administration. In the computing or drafting room, time may be saved by having available for convenient reference, drawings or other illustrations and thus reduce the amount of sketching and explanation otherwise required of the teacher.

The method of handling such details is emphasized not for the purpose of standardizing instruction, but in order that the mechanical details relating to the work of both teacher and student shall not take so much time and attention as to reduce materially the more vital matters involved in education.

It is most earnestly urged that every teacher should apply the scientific method to his teaching practice, as well as to the contents of the courses which he gives. Since all subjects cannot be most effectively taught in the same way, the best method in each case can usually be discovered only by trying experiments with different methods, the change not being too radical at one time, unless the proposed method has been tested already by the experience of others, and proved successful. What has just been said with respect to the method of instruction applies also to the contents of a course. It is very instructive to study the effect of minor changes in content. Many a course is improved by cutting out some of the material and teaching the balance more thoroughly.

Thoroughness is also needed in examining written reports in order that any failure to apply a principle correctly or to use a given method under proper conditions may not fail to be detected. Such a failure, if uncorrected, will affect work in later reports, and thus waste some time for both student and teacher, if no more serious error follows in its train. The practice of fixing dates when reports are due is calculated to encourage habits of industry and promptness. The student has a right to expect that the course is so planned in advance that if each report is completed on the given date the work will proceed practically at a uniform rate throughout the term.

It is well to keep in mind that the most careful preparation by able teachers and the application of the best methods of instruction adapted to the respective courses may fail to secure satisfactory results with some students, because of various hindrances or adverse conditions. Apart from the more generally recognized difficulties due to a lack of active coöperation by the student, there are conditions like the following: A father wanted his son to study mechanical engineering, although the son was anxious to study agriculture and then return to the west to manage a ranch; another father insisted that his son take a course in civil engineering, while he wished to take mechanical engineering; an uncle who is an electrical engineer, prevailed upon his nephew to enter a college of civil engineering, although he wanted to take an arts course with electives in finance, with a view to banking as a career. These students were deprived of the joy of work which more naturally follows the exercise of their own free choice of a course of study. At the same time, their enforced half-heartedness reacted unfavorably upon the effectiveness of teachers and fellow students with whom they were associated.

To what extent the increasing complexity of student life reduces the strictly educational work of technical colleges is a subject that merits thorough investigation and discussion. Time permits only a brief reference to it. The students who are active in athletics not only have to devote the required time for training, but find it difficult to secure the necessary time for study owing to frequent interruptions by others who want to discuss athletic affairs with them for their own gratification. Athletics, however, form only a small part of student activities. The competitions for numerous positions of honor, trust, or profit in student affairs make heavy demands upon the time and energy of all the participants. Social events seem to be growing more numerous and elaborate. The number of student organizations for a great variety of purposes is constantly increasing. This trend is due to influences outside of college life, as well as to those within it. The publicity given to such affairs serves to magnify them in the minds of young people as well as of their parents. Cases have been cited where fathers express surprise that merely scholastic attainments shall be considered in determining whether a son may remain in college or not. Student activities aid materially in the study of human nature, and have other useful functions, but they need to be kept within proper limits and subordinated to educational interests. It is not intended to imply that conditions are worse in engineering colleges than in others. It is generally conceded that throughout the country engineering students work harder than those of other colleges.

In view of the responsible work of the teacher which includes a thorough knowledge of the subject, a knowledge of human nature, as represented by students, and a knowledge of the science and art of teaching, it seems unfortunate that financial considerations in administration require so large a proportion of teachers of engineering to be of the rank of instructor. Every teacher should preferably have some professional experience, in order that he may learn where to place the emphasis in teaching, or to distinguish between what is of primary and of secondary importance, between essentials and non-essentials.

Since instructors are appointed annually in most cases, and their tenure of office is uncertain, they cannot reasonably be expected to plan their work of instruction as far in advance as those of higher grade. Some time is needed for advanced study, or for investigation, for it must be remembered that unless a teacher grows intellectually himself, he can neither inspire his students, nor maintain adequate enthusiasm in his work.

Generally, they begin their work as teachers without having previously taken courses in psychology and pedagogy. Afterwards, it is regarded as more important to devote whatever time is available in vacations to securing additional engineering practice. The subjects to be taught require so much study that books on education are neglected. Many instructors carry on work for an advanced degree as a means to promotion if it is hoped to continue teaching, or to make use of library and laboratory facilities while they are available before returning to practice.

Employment is accepted during vacations which is often not so desirable as technical experience, on account of a larger financial return, which is imperatively needed. When an institution is unable to pay a fair salary to an instructor, a special effort should be made to afford favorable conditions for doing his work and to fit himself for better service, for, in the long run, the institution is best served by those who are steadily growing in knowledge and experience.

On account of these conditions, it seems to be highly desirable for a technical college, or the university of which it forms a part, to make an organized effort to improve the teaching power of its instructors. Its cost would be relatively small, but its value would be great. It is gratifying, therefore, to know that during the past year the Iowa State College, through the initiation of its President, has given a special course of lectures on methods of teaching for the benefit of instructors. The appreciation and value of the course were attested by an excellent attendance of teachers of all grades.

The reaction of the student toward the subject to be taught depends materially upon the personal relation between teacher and student. The student needs guidance, but the teacher's aid must not lead him to relax his own effort. It requires constant watchfulness and good judgment to balance properly the activities of teacher and student. The manner of a teacher is important. If he exhibits too much dignity, it often deters the student from seeking help at the time when it will do the most good, while easy-going familiarity may lead to asking for assistance before adequate effort has been made on his own part. Perhaps a guide to good judgment in this respect on the part of the teacher is that he shall always manifest the spirit of a real friend, who is accordingly neither to be feared nor to be imposed upon.

Laziness, indifference, lack of adaptability, and other qualities lead naturally to some percentage of conditions and failures in a class at the end of the semester. Although the standards of teachers may vary more or less the law of the probability curve has been found by investigation to apply to the average. Real love for students does not imply the toleration in class of those who shirk their responsibility. The continuous presence of a few men of that type lowers the standing of an entire class. It is unfair to the rest of the class to expend much energy, time, and thought upon those who fail to appreciate their opportunity, and the sacrifices made in their behalf. Engineering colleges have been severely criticized for permitting lack of punctuality and absences without excuse from classes, because such habits, and the attitude toward work thus implied, are a detriment to young men after graduation.

Another problem for the teacher is to determine the relative attention to be given to different students with the time and strength available. Shall the intellectually weaker students receive most attention in the class so as to reduce the conditions and failures to a minimum and allow the good students to follow their own initiative with but slight help from the teacher? Or, shall it be regarded as more important to stimulate most those who manifest interest, initiative, and ability, and to eliminate the few who fail to respond to active service in their behalf, thus raising the individual as well as the average performance of the balance to as high a standard as possible? The true teacher is eager to help those of lesser ability who show an earnest desire to make the most of their opportunity. He also realizes, however, that his greatest opportunity is to inspire the ablest men with the spirit of original investigation, and to apply their powers in widening the boundaries of human knowledge. If the teacher is to stimulate students to use their creative powers, he must himself have these powers, and know how to exercise them. This implies additional time to be devoted to other work than that of the class room.

Since the progress of the student in his technical education is so vitally dependent upon his habits of study, it is surprising that but little effort is made to instruct all freshmen upon this subject immediately after entrance. It is of sufficient moment to warrant at least several lectures in which the results of psychological investigation and of experience are applied in developing the best methods of study. The cultivation of right habits and of a proper attitude of mind give increasing pleasure in study, while securing the results desired. This element of pleasure or satisfaction acts as an incentive to effort beyond the prescribed limit. In written work, as a part of lesson preparation, the practice of neatness and systematic arrangement is not merely valuable in itself, but influences in turn the whole habit of thought in scientific achievement.

When no general plan is adopted to teach methods of study to freshmen, then the duty devolves upon separate departments to do what they can toward the same end. The most effective plan is to provide printed leaflets which have been carefully prepared and which the student can study and review until he has made his regular practice conform to its directions. A model leaflet of this kind is issued by the department of mathematics of the University of Wisconsin.

The power of concentration is of such importance that it should be steadily cultivated. In working at an example, it will often be desirable to indicate in advance the conditions or to record the data in some graphic form to appeal to the eye, so that no effort of the memory is required to recall the conditions while attempting to concentrate the mind on a particular part of the solution. Diagrams are often omitted through a mistaken notion that the time employed to make them can be saved. Another habit which frequently leads to errors by distracting attention is to attempt the transposition of an equation before it is completely written out in its fundamental form, as for example, an equation which expresses a condition of static equilibrium in mechanics.

At the blackboard it is equally important to cultivate the habit of orderly arrangement, care and neatness. It is often advantageous to state in a few words what certain computations represent instead of covering the board with numerical work or equations, and to depend upon the memory to identify them. A habit to be steadily cultivated is that of always giving the analysis of the problem or the plan of attack, before taking up the detailed solution of its several parts. To go into details at the start is to change from simplicity into complexity and clearness into confusion of thought.

It is instructive to observe the additional interest manifested when the student has an opportunity of electing at least a few subjects. To make an intelligent choice, he is naturally led to discuss the matter with a few engineers in practice and then he may consult different members of the faculty who offer such courses. Much more discussion is had with his fellow students, and more or less reflection on his own part with reference to different fields of practice. It is not intended to discuss electives as related to specialization, but experience shows that the favorable attitude toward a course which he has freely selected, has been frequently followed by a marked growth in interest which is so essential in the acquisition of knowledge, and by a spirit of investigation that has revealed unexpected powers.

In discussions of technical education in recent years, writers often refer to the relative effect upon success in life of certain personal qualities or elements of character and of intellectual growth in technical knowledge, as though these two things could be directly compared with each other. No useful engineering career is possible either without technical education on the one hand, or without good character on the other; both are absolutely essential.

The teacher may properly be held responsible for some improvement during his college course of the elements of character which the student possesses at entrance, but it must always be remembered how many other influences upon them have been at work for years, and how difficult it is to change the results of their action. Some students who are reared in the city are not able to get as much out of their opportunities in college because their parents have deprived them of certain preparatory training and experience. Those who have had the chance to work with their hands during high school vacations, if not before that, who have observed business men and methods in connection with their work, and acquired some fundamental ideas of business affairs, have a considerable advantage over their fellows who have not had such opportunities, due either to the mistaken kindness or the indifference of parents.

Professor James defined character as a bundle of habits. The example of the teacher and the manner in which he conducts his work have some influence in changing or strengthening the student's habits. The teacher's example has possibilities of large influence. His sincere love of the truth, his enthusiasm in relation to the subjects taught, his industry and unfailing good will, may inspire to high ideals and achievement which only time will fully disclose.

Employers of young men turned out by engineering colleges are sometimes disappointed in their performance, and criticize the colleges for what they are not responsible. The best results of the work of teacher and student in college will not be best conserved and applied unless the employer coöperates in a further advancement of the student's educational training. If the young technical graduate is to render the best service to his employer, he must continue the habit of study, including the study of books related to the field of engineering in which he is employed, and other books to broaden his knowledge of engineering and of other human interests. It is also necessary for him to continue the habit which he has formed while in college of reading regularly one or more engineering periodicals, in order that he may learn about new discoveries or inventions, of the results of experimental investigation, of improvements in design and construction. In this manner, his interest will be increased in his own daily work, and he will gain additional preparation for subsequent work and responsibility. He will also gradually develop that professional spirit which is such an incentive to personal achievement.

An employer by occasional interviews can do much to encourage a young graduate to improve himself. The employer's experience and knowledge in his chosen field enable him to suggest lines of reading and study, and the best works available for that purpose. He may recommend some subject for research to which spare hours can be applied, and thus stimulate the desire to render some service to the world by adding to the sum of human knowledge. The rate at which an employer places increasing responsibility upon a man has much to do with the progress of his achievement.

Some years ago, several corporations like the Westinghouse and the General Electric Companies placed young college men into special apprenticeship courses, but with no more attention than that received by any other apprentice from the foreman under whom he worked. More recently, these men are also placed under the direction of men who are older technical graduates, and who give special instruction in classes partly during the time of the employer, and partly in evening classes. This instruction is carefully coördinated with the shop practice of the men.

There are numerous indications that serious study is being given to the importance of this subject, and some leaders have announced the adoption of definite plans to train technical graduates for positions of larger responsibility in practice. The practical experience required for the purpose is to be secured through carefully organized courses in practice just as the theoretical training is obtained through organized courses of instruction.

The *Bulletin* of the American Railway Engineering Association for October, 1915, contained an article by Earl Stimson, engineer of maintenance of way of the Baltimore & Ohio Railroad, entitled "A System of Standardizing Maintenance of Way Work." In the summary occurs the following paragraph: "By no means the least of the benefits to be derived from this system is that of the development of the young engineer from an inexperienced transitman or draftsman from the engineer's office into a well-qualified candidate for the position of supervisor or assistant division engineer, from which position he will later qualify for that of division engineer."

The superintendent of a division of the same railroad has a scheme by which he advises young men who are not technically educated on reading and study required for different positions. A similar plan for technical graduates could be employed to mutual advantage.

Last fall, Mr. E. M. Herr, president of the Westinghouse Electric and Manufacturing Co., made the following statement in a public address:* "In the last analysis, it is the man behind the gun who counts, no matter what is his position in the industry, be it high or low. Let us, therefore, consider what facilities, what incentive, what inspiration, what outlook, is given for individual improvement and growth. We apply reserves and depreciation to our buildings and machinery that they may be kept up and developed to a better and better efficiency. We should apply the same principle to our men, only on a broader and more liberal basis, because of the far greater asset value of the human element than the material to the ultimate success."

When it is considered how important the function of the teacher is in giving young men their education in fundamental principles and methods, and how much the habits and spirit of the teacher influence the student both in and out of the class room, it is apparent that the utmost care is needed to secure not only teachers of ability, but of the highest character. Attention is often called to the need for men of broader education and intellectual interests, but not so frequently to the equally great need for men who represent the best type in moral and spiritual culture. The college is too frequently regarded merely as an intellectual workshop instead of an institution for the building of men who shall go out into the world, not only to take a worthy part in professional life and the material advancement of the country, but to give at least active support and coöperation with plans for social and civic improvement in the community, state, and nation. Education is incomplete with mere instruction. It must also train the feelings and challenge the will. If students are to go out from college with high ideals of unselfish service, they need to come into association with teachers in college who embody the same ideals in their lives.

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* See *Railway Age Gazette*, Vol. 60, page 297, Feb. 18, 1916.

REPORT OF COMMITTEE ON COMMITTEES.

Committee No. 4.

BY G. R. CHATBURN.

The Committee on Committees held three meetings at the time of the annual meeting of the Society last June, at Ames, one of them occupying nearly an entire afternoon. The committees for 1915–16, their composition, and the assignment of subjects, were recommended to and adopted by the Society and made available to every member by subsequent publication.

The present report may, therefore, be confined appropriately to a consideration of the general policy to be adopted in order to make the committee work most fruitful and effective. Each subject to be assigned should be carefully limited in scope, so that the questions to be sent out for information may not require a burdensome amount of labor to answer. Several short questionnaires from different committees are more likely to receive proper attention from the members of the Society, or from other administrative officers in engineering colleges, than if an elaborate one is received from a single committee. All questions should be as definite and specific as possible, or else the answers are likely to be vague or too general to be useful.

Every effort should be made by the chairman of a committee to have the questions prepared in time to be sent out not later than November by the Secretary's office, if the report is to be completed for the following annual meeting. After allowing a reasonable amount of time for replies, some follow-up letters may have to be sent out. Active work upon the information gathered can usually be best accomplished if divided among two or more subcommittees and the results from each one submitted to the others. Some report should be submitted by every committee to the Secretary, and not later than April 15 if it is to be published.

If all the committees are active, the reports will naturally become more voluminous than the Society can afford to publish in the *Bulletin* or PROCEEDINGS. Each report should, therefore, be so framed that the most essential part for circulation may be published while the rest of it may be filed for reference in the Secretary's office for the benefit of those who are particularly interested.

Whenever possible, a report should contain some definite recommendation or statement by the committee which, after thorough discussion, may be adopted by the Society, either with or without amendment.

The experience of other societies shows that the best results are obtained if committee work is practically continuous. To secure this result, more than one topic may be assigned to a committee, it being understood that final reports are not expected on all of them at the following annual meeting. Under this arrangement, sufficient time may be taken to arrive at a satisfactory conclusion and report.

In order that work on any committee may not become a hardship, it is generally desirable to change its membership in part each year. This change should usually involve only the minority of its members, in order that the majority may be familiar with the work of the preceding year. In this way the Society will secure the benefit of the experience of a larger number of members and relieve for a time those who have rendered good service.

Each committee should consider what subjects ought to be studied during the following year, and submit their recommendations to the Secretary of the Society. Similar recommendations may properly be made by any other member of the Society. The Committee on Committees will then select the topics which seem to be most timely, or the most important.

REPORT OF JOINT COMMITTEE ON ENGINEERING EDUCATION.

Committee No. 5.

BY DESMOND FITZGERALD.

I seem to have but one idea in my head today, and that is, that I love Virginia. I see you all know who Virginia is. I came here prepared to love Virginia, because I never heard a Massachusetts man in all my life say anything but words in commendation of her; then she is our elder sister—just enough older to be interesting, and if she is beautiful too, that only adds another reason why we should adore her.

In regard to this University, one word: I must say I can hardly realize that one of the dreams of my life has come true, and that I have really seen this beautiful campus and this wonderful work of Jefferson. Is it not gratifying to think that during his own lifetime he saw the main features of this plan carried out! Yes, it seems to me like the realization of a beautiful dream. This campus, surrounded by this simple but lovely development of the Colonial style could be used in many places in our country as a type worthy of being copied.

But I must not forget our work. I have only a few words to say, because I know you are all waiting to hear the more interesting report of Dr. Mann, the great central figure of this Joint Committee on Engineering Education. Large committees as a rule are not desirable but I believe thoroughly that our large committee in this case has proved really useful as an advisory committee. We are trying to do all that we can to help Dr. Mann. If he is pleased with our help, I know we are more than pleased with his accomplishment.

We are a somewhat ancient committee. It almost seems to me that we are entitled to a pension. But think what a good work we have done, for we have kept the cranks from dominating our work. Now, I thank Heaven that there are plenty of cranks in our profession; we could not get along without them; but all the same, you have to keep your weather eye open for them. That is one reason why I, for one, have stuck to the Committees for eight years. They have tried to snow me under several times, but somehow or other I am still on the job.

After we had spent all our spare cash in carrying on the work of this Committee, we naturally turned our eyes to the Carnegie Foundation; and fortunately Dr. Pritchett came around to our way of thinking, and said he would take hold of it; and the grand old man who has done so much for us in so many ways is now putting his shoulders to the wheel, and Dr. Mann with reasonable assistance in the way of a staff is carrying out the work.

I wish to say a word in regard to Dr. Mann's idea. I think he is a wonder. I think it is remarkable that a man could, in so short a time, have developed such a fundamental and simple solution of the great problem upon which we were working.

I had the pleasure of attending recently the graduating exercises at Phillips Academy—I am an alumnus of the Academy. Dr. Stearns, who is an admirable man of fine ability and character, dwelt on the great importance of character in the graduates. I was pleased, and knew that Dr. Mann would agree. I saw another side of it. Dr. Stearns was looking to the sending of men out to do the work of the world, and do it successfully, because they had the foundation for it in character. I liked that. The other side of it is that engineering must be taught so as to develop men of the same sound character.

I wish you gentlemen to think of this seriously in all its bearings and in all its aspects—and the more you think of it the more you will see that we have here, through Dr. Mann's discovery, a measuring stick, a yardstick by which you can all measure the value of your own work, whether in physics, or civil engineering, or sanitary engineering, or mechanical engineering, or electrical engineering, or chemical engineering; in all these studies you can measure the success of your work with your boys. Is your work having the effect on your classes of giving them resourcefulness and character; the ability to think for themselves, expanding their minds? Or, are you simply trying to cram facts into them without developing character?

Now, I hope you will look at it from all sides; and undoubtedly Dr. Mann will picture it from all sides. I have taken this extra time but will stop now, because I know his words are of more value than mine. I hope he will iterate and reiterate this simple idea so that we get it fully into our minds, for this is not simply a theory, it is a fundamental principle and one, I believe, of great value.

REPORT OF PROGRESS IN THE STUDY OF ENGINEERING EDUCATION.

BY C. R. MANN,

Carnegie Foundation for the Advancement of Teaching.

The chairman of this Committee and others have expressed their confidence that a great deal of good will come from this study. This seems probable for two reasons. One is that it is being guided by so able and so devoted a committee. The other is that the schools have welcomed the study and shown a hearty willingness to cooperate in every possible way. Under such conditions, how can anything but good result?

Last year it was reported that the study was being carried on under four heads:

First, a historical study, for the purpose of defining the meaning of the words "American engineer."

Second, a study of the professional demand, to determine what it is that the professional engineer expects the school to achieve.

Third, a study of the schools in detail, with an analysis of their work with reference to the demands of the engineering profession.

Fourth, an investigation into objective methods of testing school work;—of finding out whether men are competent to enter the engineering schools; and how effective the work is when measured by its results.

I. The Historical Background.

The basis of the American system of education was laid by the general court of Massachusetts in two acts passed in 1642 and 1647, respectively. These state that the aim of education should be to secure four concrete ends of great value to the church and the commonwealth. These ends were, for the church, that every one must (1) learn to read the Scriptures and the catechism, and (2) have the free opportunity of entering the ministry through the grammar school and the college; for the commonwealth, that every citizen should learn (3) the capital laws of the colony, and (4) some gainful occupation.

At the time that this legislation was enacted the only occupations open to graduates of the college were those of minister, teacher and gentleman. The great majority of the people, including physicians and lawyers, learned their trades by the apprenticeship system. Therefore the responsibility for their education was divided between the schoolmaster and the master of apprentices. The schoolmaster was "to teach all such children as may resort to him to write and reade"; and be "able to instruct youth so farr as they may be fited for the university." The master of apprentices was to train them "in some honest lawful calling, labour or imployment, either in husbandry or some other trade profitable for themselves and the Commonwealth."

This division of the function of education between the schoolmasters and the masters of apprentices was inevitable under the social and industrial conditions prevalent in the colonies. In time, however, schools came to be regarded as constituting the whole educational system, and the fact that the training of every one to some "gainful occupation" is one of the important justifications of taxation for public education was forgotten. The magnificent service which the schools have rendered in conserving ideals in America is fully described in the standard histories of education. But the industries and mechanic arts, which have rendered a no less magnificent service in expressing American ideals and developing the American spirit, have received but scant recognition as essential elements of the national system of education. Since the industries and the mechanic arts have laid the material foundations of the United States and created the demand for engineers, it is not possible to understand engineering education without at least a brief sketch of the development of the demand that training in the practical arts be reinstated as one of the four essentials of a complete education.

The industrial history of America begins even before that of the schools. The first ship built by white men on this side of the Atlantic was launched in 1607 at the mouth of the Kennebec. A tannery was established at Lynn in 1629. In 1640 the General Court of Massachusetts directed the magistrates to consider "what course may be taken for teaching the boys and girls in all townes the spinning of yarn." By 1690 the American weavers of woolen cloth had become such successful rivals of the British weavers that Parliament passed the Woolens Act which forbade the colonists from transporting woolen goods from one place to another for the purpose of sale.

"In 1718 a great stir was created in the town (Boston) by the arrival of a number of Irish spinners and weavers, bringing the implements of their craft. Directly the spinning craze took possession of the town and the women, young and old, high and low, rich and poor, flocked into the spinning school which was set up on the common in the open air. Prizes were offered for the best work and the enthusiasts went about proudly clothed in the homespun products of their own hands."

A special town meeting was held at the town house September 28, 1720, at which it was voted "that the Town will proceed to the choyce of a committee to consider about promoting of a Spinning School or schools for the instruction of the children of this town in Spinning." This committee recommended the erection of a suitable house and the employment of a weaver "having a wife that can instruct children in spinning flax, to take care of the school." This project was not carried out till 1753 when a wheel tax was levied, £1,500 raised, and the Manufactory House built for this purpose. In 1765 the Daughters of Liberty resolved to wear only homespun, and the seniors of Harvard College agreed to take their degrees (1768) " dressed altogether in the manufactures of this country."

It is a well-recognized fact that the efforts of the British to crush American manufacturing industries were among the chief causes of the Revolutionary War. The only positive action of the first continental congress (1774) was its non-importation agreement, aimed at establishing independence in productive industry. After the Peace of Paris, under the confederation, each colony controlled its own trade. Because there was thus no concerted action with regard to industrial protection, England was able to flood the American markets with foreign goods which were sold at prices with which home manufactures could not compete. American industry was paralyzed, money became scarce in America, and the working men were idle.

To meet this situation, associations of mechanics and tradesmen were organized in various parts of the country. These took an active part in the struggle for the ratification of the constitution in the ardent hope that a federal government would be able to protect and encourage American manufactures. In this they were not disappointed, for the first act of the consolidated government (1789) was a statute for the joint purposes of ''raising revenue and protecting manufactures by laying duties on goods, wares and merchandise imported.'' The first federal patent law was passed in 1790.

Not only were the manufacturers protected from foreign competition by the federal tariff, but they were also encouraged by financial aid from state legislatures. A bill levying taxes for the support of associations for the promotion of agriculture, manufactures and the useful arts was introduced into the Pennsylvania state legislature in 1798. Other states followed suit, but the first to vote funds for this purpose was New York. In 1819 an appropriation of $10,000 a year for two years was made. This state support led to the establishment of twenty-nine county societies for the promotion of agriculture and domestic manufactures during the two years.

This protection of American industry by the federal tariff and by state support seemed necessary at this time because the use of machinery and the factory system had progressed further abroad than it had in this country. In order to maintain this advantage, Parliament had forbidden the export of machinery to America. In 1788, however, Samuel Slater, a mechanic who had had experience with the British machines, escaped to America and built from memory similar machines here. Under his direction the first successful cotton mill driven by water power was established at Pawtucket in 1790.

The invention of the cotton gin by Eli Whitney in 1792, the application of steam power to navigation by John Fitch (1790) and Robert Fulton (1808), the development of machinery for threshing grain and milling flour by Oliver Evans (1791–1804) gave great impetus to these several industries, and domestic manufactures advanced by leaps and bounds.

Great difficulty was experienced in obtaining operatives as the manufacturers were "required to raise up an entire new set of workmen from amongst our own Youth at a heavy expence." These operatives were poor children seven to twelve years old whose parents had been able to give them small opportunities for schooling. Therefore, in 1793, Slater established at his own expense a "Sunday School" where these children were taught the three R's by students from Rhode Island College. These Sunday Schools were the precursors of the mechanics institutes.

As the manufacturing industries developed and machinery came to be used more and more, the difficulty of securing skilled labor increased. Signs of exhaustion of the soil also began to make it evident that more intensive and scientific methods of farming must be introduced. In 1818 there was published in the *Gentleman's Magazine* the first account in English of the Fellenberg industrial school at Hofwyl, Switzerland. The Hofwyl school was first established as a charitable enterprise for the education of poor children. Its work was such a marked success that the children of the rich soon sought admission too. Its aim was the development of character by all round training. Careful attention was given to physical health and to recreation by change of employment. Time was judiciously divided between books and the work of caring for the place. Sound morals were inculcated through good books, good environment, self-government, no prizes, and mutual confidence among instructors and students. The plan and methods of this school seemed so well suited to the needs of the situation in America that a similar school was established the next year by Josiah Holbrook at Derby, Connecticut.

This school was not a success, but the idea spread; and in 1823 the Committee on Agriculture of the New York Legislature made a report in which the establishment of a state school of agriculture was urged. The institution was to be modeled after the Fellenberg school to consist of (1) a model farm; (2) an experimental farm; (3) a manufactory of implements of husbandry; (4) a school of industry and mechanic arts; (5) a boarding school; and (6) an institute of theoretical and practical agriculture. Arguments were adduced to show why such a school would benefit agriculture, commerce, manufactures, the morals of society, the revenues of the state, and politics.

This report closes with the remark "The Hon. Stephen van Rensselaer has offered a gratuitous deed of the lands required for the use of the institution." The legislature failed to adopt the report and the next year van Rensselaer proceeded to carry out the project alone and founded the Rensselaer Polytechnic Institute, the first engineering school in the United States. The methods of instruction introduced into this school by Amos Eaton, its first director, were original and somewhat different from those of the Fellenberg school.

At this same time the public schools reached, according to the histories of education, the low water mark of their efficiency.

The year 1824 witnessed the inauguration of another enterprise which has been of far reaching usefulness to technical education. Samuel V. Merrick inherited that year a machine shop in Philadelphia. He soon discovered that he could not manage it intelligently without some knowledge of machinery. Although the University of Pennsylvania had in 1816 "created a new department to be devoted to the study of natural science,'' and although five professors were still holding chairs in that department, Merrick was unable to get the kind of instruction he needed. He therefore decided to establish a new school. Professor Keating of the university department of applied chemistry joined in the venture. This combination of Merrick's need with Keating's knowledge proved effective. The Franklin Institute was established. One of its first students, a bricklayer named Thomas U. Walter, designed the dome of the Capitol at Washington.

From 1825 to 1860 the industries developed rapidly. Canals and railroads were built, the McCormick reaper, the sewing machine and the telegraph were invented, and the Atlantic cables were laid. The west was settled, the federal finances prospered. and state school systems were developed. Every new stage of advancement in material prosperity and every new invention served to intensify the demand for greater knowledge of science and greater skill in the useful arts. This national demand had become so insistent by 1857, that it could no longer be ignored. The Morrill bill was introduced into Congress, and became a law in 1862.

It is important to note that this response to the national demand for practical knowledge came from the federal governmen. State school systems had been established by each state independently and on traditional lines; but this act calls for a new American type of school ''to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life.'' It is also significant that the father of this land grant college bill was father of the tariff act of 1861, and that bills increasing the federal bounties to these colleges were introduced into Congress during the tariff discussions in 1872, 1884 and 1890.

The decade from 1860 to 1870 witnessed the establishment of several of the most celebrated engineering schools. In following their subsequent development it is important to recognize clearly that their origin was very different from that of the schools of law and medicine. These latter were first established by practitioners as an outgrowth of the apprenticeship system and were usually well developed as professional schools before they became affiliated with the colleges. The engineering schools, on the other hand, were not founded by engineers as the outgrowth of an apprenticeship system, but by college professors who sought to satisfy industrial needs by the methods to which they were accustomed in the colleges.

Yet notwithstanding this close kinship of the engineering school to the arts college, the scientific school was kept distinct from the "college proper." The students preparing for an industrial profession were not considered as of the same caste with those preparing for the "learned professions."

This feeling in the colleges was reflected in the public schools which were still oblivious to the fact that training for a "gainful occupation" is one of the four fundamental justifications of taxation for public education. The lowest depths of this oblivion were reached in the report of the Committee of Ten (1895) when languages, mathematics, history, natural history, physics, and chemistry, were declared to be the only subjects "proper for secondary schools."

The achievements of engineering have, however, forced the recognition of the fact that knowledge of the practical arts is essential to the education of every American. The demand for vocational education is omnipresent, and the schools seem to be about ready to follow the lead of the engineering colleges in so teaching the mechanic arts that their educative power shall be felt by everyone. Since the apprenticeship system has now practically disappeared, this introduction of the industrial arts into school work is necessary before the schools can justly claim to give a complete education, *i. e.*, one that confers all the benefits on the church and commonwealth which the founders of the American educational system had in view.

For the past fifty years engineers have been absorbed in the work of inventing, constructing, and perfecting machinery and the material conveniences of life. A large field for usefulness along these lines will always remain open to them. But the methods of this work have now been standardized and reduced to a system. Every large plant has its designing department and even its research laboratory.

Relatively little attention has as yet been given to the scientific study of problems of the organization and control of the forces of men. These problems of human machine design and the conservation of human resources are as much engineering problems as are those of mechanism and the conservation of material resources. The demand for creative work in this field of human engineering is daily becoming more insistent. Can the engineering schools longer afford to ignore it?

Again, American industry has developed in a land of abundant natural resources. It has always been protected by a tariff which has been raised as the industries grew stronger and more wealthy. This protected atmosphere of natural opulence has given strong incentive for the development of originality, initiative, and push. Every boy in America has felt that the opportunity to become president was open before him. There was, however, little incentive for economy of production. It was much easier to exploit the Indians or to persuade Congress to raise the tariff than it was to make a scientific study of production costs.

The increase in population and the waste of natural resources have now brought the United States under the operation of the law of diminishing returns. The problem of efficiency of production has been thrust upon us. This again is an engineering problem. It cannot be solved here by merely copying the autocratic methods that have been used successfully elsewhere, but demands an American solution which shall insure efficiency without sacrificing individual spontaneity and initiative.

These then are the three problems of the immediate future for the American engineer. (1) To introduce the practical arts into the schools in such a way that all may share their educational value. (2) To devise human machinery that shall assure to every American justice and a fair show. (3) To develop the highest efficiency of production,—an efficiency which is attainable only when individual initiative is given the freest play.

II. The Professional Demand.

The returns from the circular letter sent out in the spring of 1915 were summarized and the results announced at the meeting of the American Society of Civil Engineers last January. Because of the rather unexpected nature of the summary and its importance in defining the work of the schools, the Joint Committee on Engineering Education last March sent to the members of the National Engineering Societies the following card:

> Please prefix numbers to the groups of qualities listed below to show the order of importance that you give them in judging the reasons for engineering success or in sizing up young men for employment or promotion.
>
> ....Character, integrity, responsibility, resourcefulness, initiative.
> ....Judgment, common sense, scientific attitude, perspective.
> ....Efficiency, thoroughness, accuracy, industry.
> ....Understanding of men, executive ability.
> ....Knowledge of the fundamentals of engineering science.
> ....Technique of practice and of business.
> Submitted by ....
> Address ....
> Years in practice ....

Up to June first, 6,773 of these cards had been returned; 352 were accompanied by letters explaining the views of the writers.

A statistical summary of the returns was begun on May first, when 6,069 cards had come in. Of these 5,441 were regular, each one rating the six groups in the order of importance by some single combination of the numbers 1–6. There were 489 irregular cards, in which one or more of the numbers appeared more than once or in which the qualities were weighted by percentages instead of being numbered. On 139 cards the qualities were numbered in two or more different orders, one for engineering success, another for employment, etc. The regular cards were sorted according to the number of years in practice and the vote counted separately for each five-year period. Cards on which the years in practice were not given were counted together.

Differences in years of practice were found to make but little difference in the vote. The following table gives the regular vote by ten-year periods. The table reads: Character was rated higher than judgment by 84.8 per cent of the voters who had less than ten years of experience, by 86.6 per cent of those with from ten to nineteen years of experience, etc. The last column gives the percentage vote on each item for all the 5,441 voters.

	Years in Practice.				
	Under 10.	10–19.	Over 20.	Not Given.	Total.
No. of ratings	1,000	2,000	1,941	500	5,441
$C > J$	84.8	86.6	88.3	88.2	87.0
$C > E$	92.5	92.8	92.5	91.8	92.5
$C > U$	92.7	93.0	95.0	95.8	93.9
$C > K$	91.8	91.9	91.0	91.4	91.5
$C > T$	97.3	98.0	98.0	98.0	97.9
$J > E$	77.8	78.7	76.3	75.4	77.4
$J > U$	80.8	82.1	84.1	82.0	82.5
$J > K$	78.4	79.7	74.7	75.8	77.4
$J > T$	96.8	96.2	95.0	96.2	95.9
$E > U$	59.7	61.5	68.5	65.4	64.0
$E > K$	65.0	63.0	64.9	64.4	64.2
$E > T$	93.9	92.9	92.7	95.8	93.4
$U > K$	57.7	57.3	54.5	52.2	55.9
$U > T$	89.9	87.1	85.7	86.0	87.0
$K > T$	92.3	90.3	90.7	91.2	90.9

The most probable values of the relative importance of these groups of qualities have been computed from these percentage votes by the method described in Chapter VIII of Thorndike's "Theory of Mental and Social Measurements." These values are given in the first column of figures. The last column gives these same values as determined by the summary of the replies to the first circular letter explained in the *Engineering Record* for January 29 and the *Engineering News* for January 27, 1916.

Because of the constancy of the percentage of the votes, as shown in the table, it is clear that this statement of the factors essential to engineering success corresponds to a rather definite ideal in the professional mind. It is therefore safe to make use of this definition in testing and planning the work of the schools.

Character	24.0		41.0	
Judgment	19.5		17.5	
Efficiency	16.5		14.5	
Understanding of men	15.0	75	14.0	87
Knowledge of fundamentals	15.0		7.0	
Technique	10.0	25	6.0	13
		100		100

When applying this definition to the schools it is desirable not to forget several perfectly obvious facts. In the first place, all the qualities mentioned are essential to genuine success and conscious effort should be made to develop all of them as far as is possible. Second, character, initiative, common sense, and qualities of this sort cannot be taught explicitly like multiplication tables and rules of grammar. Third, education is a continuous process of growth, and therefore the conscious development of the qualities of the first four groups cannot to advantage be arrested for four years, even for the sake of a mastery of knowledge and technique. Fourth, the man whose character, judgment, efficiency and understanding of men has developed most during his college years has the best show after graduation, since these qualities constitute 75 per cent of his equipment. Fifth, the fact that character is rated at 24 per cent does not mean that an engineer can succeed with a 24 per cent character. It does mean that even a perfect character is but 24 per cent of the engineer's total equipment.

With these facts in mind it is evident that instruction in mathematics, or machine design which aims only at a mastery of fundamental principles and technique, cannot be nearly as efficient as instruction which, while paying due regard to technique and the mastery of principles, yet develops integrity, initiative, resourcefulness, and common sense.

III. The Work of the Schools.

A. What Freshmen Know and Can Do.

Twenty-two schools have been visited and carefully studied. A composite picture of their work furnishes the best statement of conditions. Tests of 220 freshmen at four institutions have been conducted by Professor E. L. Thorndike. These tests furnish objectively certain facts about the human material which schools of engineering educate, showing what the members of the entering class know and can do. The following samples may serve to give some idea of their abilities.

In Algebra, nine tenths of the freshmen were able to solve the following equation: $x - 2a + b = 2x + 2b - 4a$. Only one third of them could solve the following: If $x = (a + b)/2$, what does

$$(x - a)^3/(x - b) - (x - 2a + b)/(x + a - 2b)$$

equal?

In Physics, nine tenths were able to tell what materials were needed to make an electric battery. Only one third could determine how much water must be added to a pint of alcohol 95 per cent pure to make a solution of alcohol 40 per cent pure.

Nine tenths were able to fill the blanks in the following: Light generally travels in .... lines. 100 Centigrade degrees equal .... Fahrenheit degrees. Only one third could correctly supply the missing words in: The mechanical advantage of a system of pulleys, provided no energy is dissipated inside the pulleys, is .... the number of .... of the cord supporting the load. When a mass of air is heated ...., its volume increases .... of its value at zero degrees for every rise of one degree C. in temperature.

English.—In English, nine tenths could classify as animal, flower, boy's name, book, something good or bad to be or do, the following words: zachary, dexterous, hyacinth, clematis, callous, mastodon, caribou, julian, ruthless.

Only one third could similarly classify: predatory, breviary, sophistical, campanula, pusillanimous.

Nine tenths could fill in " a body of ...... entirely surrounded by ...... is called an ...."

Only one third were able to make sense out of "Let us briefly examine the social forces ...... at work concentrating or ...... the ownership ...... wealth."

Nine tenths could write the answers to the questions on the following paragraph:

"It may seem at first thought that every boy and girl who goes to school ought to do all the work that the teacher wishes done. But sometimes other duties prevent even the best boy or girl from doing so. If a boy's or girl's father died and he had to work afternoons and evenings to earn money to help his mother, such might be the case. A good girl might let her lessons go undone in order to help her mother by taking care of the baby."

1. What is it that might seem at first thought to be true, but really is false? ....
2. What might be the effect of his father's death upon the way a boy spent his time?
3. Who is mentioned in the paragraph as the person who desires to have all lessons completely done?

Only one third could answer the questions on the following:

"A chief characteristic of science, then, is that in supplementing given facts it supplements them by adding other facts belonging to the same sphere, and eventually discoverable by tracing the given object in its own plane through its continuous transformations. Science expands speculatively, by the aid of merely instrumental hypotheses, objects given in perception until they compose a congruous, self-supporting world, all parts of which might be observed consecutively. What a scientific hypothesis interpolates among the given facts—the atomic structure of things, for instance—might come in time under the direct fire of attention, fixed more scrupulously, longer, or with better instruments upon those facts themselves. Otherwise the hypothesis that assumed that structure would be simply false, just as a hypothesis that the interior of the earth is full of molten fire would be false, if on inspection nothing were found there but solid rock. Science does not merely prolong a habit of inference: it verifies and solves the inference by reaching the fact inferred. The contrast with myth at this point is very interesting; for in myth the facts are themselves made vehicles, and knowledge is felt to terminate in an independent existence on a higher or deeper level than any immediate fact; and in this circumstance is what makes myth impossible to verify, and, except by laughter, to disprove.''

1. According to the paragraph, what is the difference between the ether, the electrons or lines of electro-magnetic force and angels, a sun-god, or fairies, as principles of explanation?

2. According to the paragraph, by what sort of explanation of the facts of the world are the facts themselves made mere carriers of thought to conclusions in a realm outside that of such facts?

3. According to the paragraph, what are the methods and instruments by the aid of which perceived things and qualities are made the basis of a consistent independent universe?

B. What the Schools do to Freshmen.

Two thousand freshmen of the type described entered a group of schools in the fall of 1911. Of these 732 graduated in June, 1915. The other 1,268 had been ''weeded out.''

The records of the 732 who graduated from the 14 different schools showed that 382, or 52.2 per cent, just ''got by'' in physics, 52 per cent just passed in mechanics, 45 per cent in calculus, 43.7 per cent in modern languages, 43 per cent in English, 34 per cent in chemistry, and 23 per cent in descriptive geometry. These averages for 14 schools do not differ materially from those presented last year for five schools.

There are many who maintain that these conditions are most encouraging; for the fact that only one sixth of those who enter graduate with credit proves that the schools are maintaining high standards. This position would be more readily understood by the critics of the schools, who constitute the great majority of the American public, if the term standards were more clearly defined. What sort of standards are being maintained by this process? Are they standards of scholarship, standards of academic culture, standards of engineering efficiency, standards of justice, of integrity, of morality, of common sense, of accuracy, of science, of art, of freedom of achievement, of worldly success, of unity, of service, of obedience, of duty, of law and order, of aristocracy, of democracy, or of humanity? Perhaps all of these and many more are meant. It would be a real service if the exact meaning of the phrase "maintaining standards" in schools might be accurately defined.

On the other hand those who consider that this high scholastic mortality and these high percentages of low grades are proofs of the inefficiency of the schools offer many hypotheses in support of their position. Among these two are particularly suggestive. The first of these is derived by analogy from the experience of the industries with "soldiering." Under the old industrial system, workmen are paid according to the number of hours of work, and little attention is given to the amount accomplished per hour. Under this sytem the workman accomplishes as little as he dares and unions are formed to raise the time rate and to standardize this minimum accomplishment. When the reward is measured solely by time and not by achievement, there is every incentive not only for laziness but even for deliberate deception of the employer as to how much can be accomplished per hour by a willing and properly instructed workman.

The school system is analogous to this old industrial system since it awards "credits" in accordance with Commissioner Finley's "table of academic weights and measures," namely:

45 minutes make 1 hour
5 hours make 1 week
36 weeks make 1 unit
15 units make 1 matriculant
120 semester-hours make one degree

The student who puts in the requisite time with an estimated efficiency of only 60 per cent receives the same "credit" as one who achieves an efficiency of 100 per cent. The result is similar to that in the industries—many students "soldier," try to bluff their way through and even unite to create the tradition that it is a disgrace to be rated much above the pass mark.

In the industries this situation has been met first, by making a careful, detailed, scientific study of all the conditions that affect efficiency; second, by instructing the workmen in the best methods of work; and third, by making the reward depend on accomplishment. Where the old industrial system has been replaced by this new system, in accordance with the principles enunciated by Mr. F. W. Taylor, soldiering has disappeared, the workmen have doubled or even quadrupled their achievement, their earnings have increased, and they have become more contented and more healthy.

The success of this change of policy in industry makes us wonder whether an analogous change might not prove equally beneficial to the schools.

Usually the method of presenting subject matter in schools is determined by the teacher's conception of logical rigor and theoretical unity. In spite of the fact that the high percentages of failure and low grades prove that this method is not effective, very few experiments have as yet been made to find methods better adapted to the abilities of the students. But if the same scientific care were used in setting tasks in schools as is used in setting tasks in industry, would not these conditions improve rapidly? And would not school grades be a truer measure of ability if tasks were graded from easy to difficult and credits were given as is done in industry only for those actually completed?

Is it not probable that this system of awarding credit on the basis of achievement rather than on the basis of time would give to students a real incentive for real accomplishment as it has to workmen?

Industrial managers not only spend hours and days of study in adapting the task to the workman; they take great pains to see that each worker is carefully instructed in the most efficient methods of doing his work. May it not be that more time could be spent to advantage in instructing students in the most efficient methods of doing their work, instead of leaving them to devise their own methods of study?

Thus the first hypothesis that is suggested to explain the high mortality and excessive percentages of low grades is that the method of awarding credit on the basis of time, the acceptance of a 60 per cent standard of accomplishment and the assignment of tasks that are not adapted to his abilities gives the student no adequate incentive to achievement and encourages him in "soldiering" and in bluffing his way through.

Soldiering alone does not explain all the cases of failure and low grades. Many of those who are dropped from engineering schools should be dropped because they have no real inclination or ability for engineering work. A number of those dropped, however, persist in engineering work and succeed in spite of their academic shortcomings. Why are so many young men with pronounced engineering talent unable to make good in the engineering schools?

In one school some 74 per cent of the graduates had had trouble in mechanics. The work of the class consisted in the solution of many problems—apparently an excellent plan. But the first problems of the course were these: Find the center of gravity of an equilateral triangle. Find the center of gravity of the area included between three sides of a square and the semicircle described on the fourth side as a diameter. Find the center of gravity of the area bounded by a given hyperbola, its asymptotes and given coördinates. No models were supplied.

The use of these strictly Archimedean problems was defended on the ground that the analytical processes involved in their solution were those needed the following term in the solution of problems in strength of girders. Yet 74 per cent of these same students had trouble with this later course.

Why not give the real problems first? In the University of Washington, the course in mechanics, given by Professor C. C. More, is made up almost entirely of a series of real problems or projects of the grade usually found in such courses. This work was originally given in the third year because calculus was a prerequisite. The third-year men have, however, mastered it so readily that next year it will be given, calculus and all, to the freshmen. In like manner Professor Bird, of the University of Virginia, finds that laboratory problems very similar to those given in other schools, to seniors in chemical engineering can be successfully mastered by freshmen.

These examples define the second hypothesis that is suggested to explain the high percentages of failure and of low grades; namely, the work is not too hard, but it is presented in so abstract a manner that it has little or no meaning to the students.

If these hypotheses are correct, the problem before the schools is that of removing these two causes of failure. To do this, academic credit must be made to depend directly and objectively on achievement; and the work must be made more concrete.

This statement has been derived from an analysis of the work of the schools. Yet the problems which it defines are the same as those defined by the history of the engineering schools. For when the practical arts are introduced into the schools in such a way that all may share their educational value, the work becomes concrete and impelling to the student. And when academic credit is awarded on the basis of real achievement, efficiency and individual initiative increase together.

The solution of these problems will require much careful experimenting and study on the part of teachers; but as progress is made the schools will find that they are each year better able to meet the demands of the engineering profession.

For character, judgment, efficiency and an understanding of men—those personal qualities that make up 75 per cent of the engineer's equipment—develop best in men who love their work and who labor with enthusiasm and intelligence at things which they know to be worth while.

DISCUSSION.

Professor E. F. Chandler: We have had the habit for several years of giving a rapid examination in elementary algebra, along in the first week. It is chiefly of short, easy questions or problems to be very quickly answered or solved. It is somewhat on the order of mental arithmetic, you might say. If they already had presented high-school credits in algebra, but do not pass this examination, they are required either to drop the subject or else to enroll extra in a drill class for which no semester-hour credits are awarded. I think we borrowed this test from Wisconsin to some extent.

Mr. Desmond FitzGerald: I want to know, Dr. Mann, exactly what place this examination takes in the general scheme of finding the best method for engineering education. Is it the first of a series of tests you have in mind, of ascertaining and applying all through the curriculum to ascertain whether you are producing efficient engineering education?

Professor J. R. Benton: May I ask whether the purpose of these measurements is to ascertain different *kinds of ability* as distinguished from mere acquirements in the different lines of knowledge?

Dr. C. R. Mann: We hope to find tests that will test ability. If we all go to work to find them, we will find them.

Professor F. W. Sperr: I would like to ask Dr. Mann if he did not ask, "Are we adapting our instruction to suit the grade of preparation here indicated?" I think that is the meat of the whole subject; and it seems to me that a most important question is, "How are we willing or able to adapt our instruction to the peculiar preparation of the student who comes to us?'' In certain institutions we may be able to adapt our instruction to a wide range of preparation. Yet I know from actual experience that at the end of three years' labor with men who have not been in school at all since they were seven or eight years old, and who perhaps know only the first rules of arithmetic, you can scarcely tell the difference between them and one who was a high-school graduate.

While the high-school graduate may require four years to complete the engineering course, one of these men will complete the course with credit in five years, taking just a little longer. But it is a question of adapting the instruction to the man's preparation. In one institution with which I was connected, an attempt was made to take in men of that class for a short course in engineering. The men were supposed to go into the regular college class in algebra and were expected to prepare themselves in the textbook through simple equations before they came in. If this plan had been strictly adhered to, the experiment would have been an absolute failure; but as it happened, the three men who came to try out the experiment came to me after about two weeks of fruitless endeavor, and argued very pointedly that the experiment would mean failure, because they had not been in school since they were seven or eight years old and could not be expected to compete with men who had been in school all their lives. When I asked them what was the trouble, they said they could not learn that algebra. Now, based on their previous experience I gave them some practical algebra to show them how to solve some of the difficulties with which they had struggled many times. They said: ''Is that algebra?'' I said: ''Surely, that is algebra.'' ''Well, they never gave it to us that way.'' ''Well, I can teach you algebra, and I know you can learn it.'' ''Well, will you teach us?'' And I did undertake to teach them.

The following year some eighteen or twenty of that class of men came in for the short course and one of them, after a year of the regular short-course work, took on a lot of extra work the second year and led the college class in calculus. That is a simple illustration of what can be done by adapting the instruction to the man's preparation, beginning with what he is able to understand and building up on that. I think we can reduce the percentage of those who fall out, and raise the number of those who get through. Fifty per cent. failures seems too high. I don't think it is as high as that at our institution. I know that a high percentage of failures is quite popularly regarded as an evidence of the "stiffness" of the courses; but is it not rather an evidence of the stiffness of the instruction?

Dean C. L. Cory: Mr. President, I hesitate to interrupt, but personally I have not considered that the discussions so far this afternoon have been much more than interrupting the speaker. These interruptions perhaps have been desired by Dr. Mann; nevertheless it has certainly not been a formal or proper discussion of this most important subject.

In my opinion this phase of the problem of engineering education is the most important one that we have to consider. I don't know how we are to define character, judgment and the other desirable attributes of the engineer, but it is evident that these personal characteristics are most important. I therefore would like to request that a special session be held for the discussion of the subject presented by Dr. Mann.

Professor Wm. Kent: Dr. Mann wants us to show how he is on the wrong track. I have been making a study in the same direction for thirteen years, at least, how to find out how we shall get hold of the proper pedagogical methods. I have contributed something to the Society in an experiment in teaching freshman English, which is the result of thirteen years' study of that subject. All I have to say is that Dr. Mann is on exactly the right track. He is going in the right direction; and while I did criticize his questionnaire, I think he has got the right idea himself now.

I have made a little pedagogical examination which I think is worth contributing here. I tried to teach my granddaughter penmanship. I got her to get a copybook, but found that her writing was too poor for this, so I got her to try to make five straight lines on the ruled paper—just simple slanted lines. I made five, myself, as well as I could. Then I said to her: "Now, I want you to keep these five strokes all of the same height, all on the same level at top and bottom, all the same distance apart at top and bottom, and all showing the same amount of pressure, the same amount of ink on them." So she made the five lines; and they violated every one of the standards I had laid down. I showed her the errors. She said, "I see; I see." I told her: "You have seen what the trouble is; now see if you can do it better." Before she got through she said: "I can't." I said: "There is the whole thing."

The teaching of penmanship is like studying the piano. The child must first educate the eye, and then educate the fingers to do what the will wants them to do. The eye recognizes the note to be struck, and the fingers are then directed by the will to strike that note. She had not been trained in this. The study of penmanship is a serious matter. Then I found that two more things were needed—will and ambition. She did not have either. There were things needed in that little simple thing of making five straight lines, and I think these same things come in in every phase of education. If you can have a person see a thing; then try to execute that thing; if he has will and ambition, and perseveres in doing the thing, he will accomplish it. That is the contribution I have to make on that point.

President E. A. Alderman: I feel very humble in an audience of engineers. I do not feel that I have the right at all to attempt to instruct them. But I was deeply impressed with the conclusion of Dr. Mann. If I am not misquoting him, it is as if he has said to this company of men: "The conclusion of the whole matter is that if you want to improve engineering teaching in America, you must get down to the study of how to teach scientifically. You must really take seriously what has been thought of sometimes contemptuously, sometimes with a sneer, as a mass of worthless empiricisms, the thing known as educational science and work out in a scientific, patient way the methods by which access to the learning mind may be reached in the way that mind naturally learns and grows, as was very beautifully illustrated by Mr. Kent in his experience with his granddaughter and the five lines.

So as a teacher, as one who has taught and is a student of education—because that was my original field—I have a sense of elation and gratification to be present here in a meeting of engineers, perhaps the most important meeting of engineers that could be held in America, to hear a man who has made a scientific study of the whole subject come to the great conclusion that there is *in posse* if not *in esse* a science of education, and that all those who teach engineering, with all its science and all its practicality, are not above learning its essential principles.

Dr. Mann: My observation would confirm what Dr. Bishop has said; that is, that technical subjects do seem to be more efficiently taught than the theoretical subjects. It is not that the technical men are better instructors, or better masters of pedagogy; but it seems to me that it is because they are in immediate touch with real things; and the student gets a conception of the fact that the problem is real.

This raises a very interesting question, namely, whether we do not make a mistake in putting generalized, abstract subjects at the beginning of the course. We have chemistry in the first year; physics in the second year; mechanics in the third year; calculus usually in the second year; and we say it is impossible for a man to do his mechanics until he has had calculus, for instance. So we proceed to teach him this highly developed, to him utterly abstract subject, in order that he may prepare for mechanics, which comes later. It is another of those preparedness fallacies.

The experiment is being tried in Seattle, Washington—and there is a gentleman here from Seattle who might tell us of this—by Professor More, in the department of mechanics, who has been teaching mechanics by means of a series of projects. He does not demonstrate theoretical, abstract theorems before the class, and then draw conclusions; and say, "Now, this is the application of mechanics." He takes real situations, and describes them to his students, putting them before the boys as projects. What are you going to do under such and such conditions? From such real problems he gradually evolves the whole subject. The work is all done in the class; and he has been so successful that he is going to transfer the study of mechanics to the freshman year next year, so that the freshmen may experience the joy during their first year of having something real come into their lives.

Professor A. M. Greene: I would like to ask if Dr. Mann has endeavored to get from members of the other professions what their requirements for a successful professional man would be. It seems to me that if the doctor and the lawyer were asked the same question as has been asked the engineer. we would probably find that their seventy-five per cent. of requirements would be requirements of character, and that twenty-five per cent. would be knowledge and technique. It seems to me that the requirements which Dr. Mann has found through his questionnaire are really the requirements of life. The successful man must be a man of integrity, a man who is honest and true; and then along with that, twenty-five per cent. of professional excellence. I wish that some report could be made along that line also, if possible.

Dr. Mann: The answer to that is Mr. Dewey's famous saying, "Education is not preparation for life: it *is* life." The requirements for the engineer are identical with the requirements for the doctor, except that you must change one word. If you change "engineering science" to "medical science," then you have the doctor. Change it to "legal science," and you have the lawyer.

Dean Cory: Yesterday President Alderman said—and if I quote him inaccurately I trust he will correct me—he believed that of all professional men the engineer should be able to think straight.

Certainly the engineer should be able to think, and to think *straight*. Last year at the Ames meeting of the Society I made an appeal for the teaching of the fundamentals of engineering, and particularly for the teaching of students to think; not only to think, but to think straight and to keep on thinking to the end. This is the work of the man who undertakes to teach engineers.

Dr. Mann has said "education is life," and I have only words of commendation not only for the information that this committee has placed before us, but for the manner in which it has been done by Dr. Mann. I think it is obvious to us that the information placed upon the blackboard yesterday came from the best possible sources; from the men who have the best ability to estimate our university graduates.

These engineering graduates leave the university, they enter the world to work, the employers of these young men have given to the committee their idea of what these young men should be, and as a result we have what has been called "the yardstick of the engineer." It is in reality the yardstick of life. I have heard it said here at this meeting that perhaps we have not gotten the truest measure of the situation. Possibly we have not, but it seems to me unquestioned that the work the engineer has to do to-day is very much broader and far-reaching than when many of us graduated from the universities twenty-five or thirty years ago.

I want to say a few words as to the duty of the teachers and their relation to the students. You cannot possibly develop character in a man unless you come into personal contact with him. There is not a teacher in this room who can materially affect the character of the members of his class when he has 100 or 150 students in the class. Under such conditions personal influence is well nigh impossible. In this connection I beg to suggest for your consideration the experiment we have tried in the engineering colleges at the University of California. We were considerably concerned because so many students dropped out at Christmas time or at the end of the year semester. Students as well as instructors generally refer to this catastrophe as "flunking." Our half-year is about eighteen weeks in length. At the end of the first six weeks every instructor is requested to send to the officer of the recorder the names of all the students in his classes who are deficient either in scholarship or attendance. A copy of the report from the recorder's office showing the deficiencies of each student is sent to the dean of the college in which such student is enrolled. Another copy is sent to his parents, another to his fraternity or club, and a final copy is sent to the student himself.

When a batch of these reports is received in my office, for instance, the report of each particular student is pasted on a piece of ordinary letter paper 8½ × 11 inches in size. The young man is requested to call at the office and when he comes he is asked wherein his difficulty lies, and why his work has not been up to the mark. At the end of the second six weeks of the term a similar mid-term report is received and this is also placed upon the same piece of paper. At the end of the third six weeks we have the final mark for the term, and this is also available in the office of the dean. As a result, each student who is not doing satisfactory work has a record kept at intervals of six weeks, and he has an opportunity to discuss with the dean of his college the whole subject of his scholarship.

Let me tell you what has occurred. Of a freshman class of about 200 in the college of mechanics we find that in the first six weeks from 150 to 160 will get one or more deficiency reports. That of course does not mean that all of the students are seriously deficient; it simply means that a great number will have a deficiency report in a single subject. There are, however, some who achieve the distinction of having deficiency reports in nearly all of the subjects taken by them.

In this way we have each man's record complete. These records are classified as to the subjects in which the student is deficient. As a result I can assure you that we have learned something about the courses of study and the way they are given. When we find that 40 to 50 per cent. of the students are deficient in any particular course our Committee on Instruction of the Engineering Division begins to examine that course rather carefully. We are honest enough with the student to look into the details of the way such a course is given, and ascertain whether the excess of deficiencies is not due more to the course than to the students themselves. One must not forget that you can not develop character in a man if he feels that he is not being treated fairly. The end of the term arrives. More often than otherwise during the term the student has been encouraged by these personal conferences with his dean. At such conferences, however, it is made clear to him that unless his work improves he will not be able to complete his course and may not be ''among those present'' during the second half year. He must receive passing marks in one half of the units he is taking in any term in order to continue in college. For the athlete he must pass two thirds of the units in which he is enrolled in order to represent the university in any intercollegiate contest.

All this means personal meetings on the part of someone in the faculty with some 100 to 200 men in order to find out the individual difficulties these men are encountering in their college courses. It came to my mind yesterday when Dr. Mann was talking of the tests which could be applied to determine whether a student is qualified to study engineering. These reports make it possible for us to differentiate between, for instance, the young man who has had inferior preparation and who is working perhaps in an automobile repair shop so that he can support himself while going to college, and the young man who has had the best possible opportunities in preparation but who is handicapped by an overfond grandmother who is continually worrying about the health of her only grandson, fearing that he may study too hard. It is very much worth while to be able to differentiate between these two classes of students, and I beg to suggest that possibly some such method of finding out whether a man is qualified to become an engineer or not is a better test, since it is carried through an entire term of work, than if we attempted to arrive at the same result in a less thorough manner.

Personally I have found that these meetings or conferences with students are mutually beneficial. The personal and human side is brought to the surface. Possibly character is developed. Certainly the necessity for conscientious work is brought home to the student. The value of service is accentuated. The things he must do in life to succeed are pointed out. Dr. Mann's report for the committee indicates that all of these are perhaps more than ever required at the present time.

Dean W. M. Thornton: This subject has been already presented from many points of view. My point of view is that of a man who has been teaching for forty years in this work. I am going to venture to say that the results of the analysis Dr. Mann has given to us confirm very clearly the lessons I have learned from my classroom experience; but in a way somewhat different from the way in which he interprets them.

My experience is this: that any teacher who tries to individualize his men could form a class in which ninety-five per cent. of the men would be able to do the work. Almost everybody makes a few mistakes in classifying students; but in general I should say ninety-five per cent. could be correctly placed by a careful teacher. As it is, we get perhaps fifty per cent. past the grade line. My own belief is that this difference represents differences of character, not of qualification, not of ability. Almost any one of that ninety-five per cent. of the class, if he will apply himself earnestly and consistently and courageously, can do the work, and do it very well. Those who break down, break down through lack of character. They break down because they have not courage, because they have not faith, because they are self-indulgent, because they are spoiled by having too much money.

Most college failures are failures of character. Most students fail because they have not the grit to succeed; and for no other reason in the world. Any plan, it seems to me, that says we are going to get them all through, is not a plan to build up character. Character will be built up by letting the students know they must exert the moral qualities we want them to have. If they cannot exert those qualities, they will fail.

The examination is a test of character. It is not so much a test of the ability of the teacher to teach; because we are all doing our level best. To me every examination period is a period of penance. I think all teachers hate to reject a man. To many it is a genuine pain and a humiliation. But we have to reject them; not because the subject has not been taught properly; not because the teaching has been directed above the heads of the students; but because the men have not done their work, have laid down, have not had the grit or character necessary to command success. The chief object of teaching is to build up character. I do not believe that all the pedagogical work in the world will ever revise that.

Professor F. F. Thompson: It might seem necessary, for the sake of the able man with poor preparation, who perhaps would fairly come in as a conditioned student, that the admission test should not be too severe. There are many such cases that have occurred in my experience, of men coming up with poor preparation, who perhaps, strictly speaking, ought not to be admitted; but after such a man is in the class for three months he has demonstrated thoroughly that he is fully entitled to go on. It is difficult to get a test which will let this man in, and keep the poor stick out.

Dr. Mann: That is the point we want to hit. Is it possible to get a test more or less independent of the particular technique of mathematical ability?

Professor Thompson: Isn't it a fact that after the first month or six weeks of this man's presence in college, when he is in a new environment, he is all at sea, perhaps; and when he is given the test, he breaks down, possibly. Put him to a more severe test a month or two later, and he will go through with bells on. He has found himself. What are we going to do about that?

I think that if they could find a *real test for ability,* Mr. Carnegie's millions would look like thirty cents.

Professor H. S. Philbrick: This report is very interesting and very helpful; but I wonder if it has met the entire situation. Perhaps it is not intended that it should, at this time. Dr. Mann has assumed that the division of seventy-five and twenty-five per cent. means something; suppose we go on that assumption. The report has confined itself almost entirely to the twenty-five per cent., pointing out how properly to handle these things which come in the twenty-five per cent. The suggestions made are very pertinent. We must do the thing, and do it right.

But suppose we do do it; then what about the seventy-five per cent.? One of two things should happen, I think. One is that the engineering schools should either disclaim the responsibility for the seventy-five per cent., or should find out just what that responsibility is, and find out how to meet it. Character certainly can be strengthened by proper teaching and by proper studying; but it cannot be done wholly in that way. Men have broken down in character who have been good students; a man may be a good student and lack common sense; he may be a good student and lack the ability to judge men.

I would like to ask Dr. Mann if he would propose to study that seventy-five per cent., and find out what the limit of responsibility is which the engineering schools should assume, and how they should tackle the problem. I think that seventy-five per cent., if we assume that the engineers are right in their percentage, should be scrutinized as carefully as the twenty-five per cent. has been.

Mr. C. R. Dooley: I would answer the last speaker this way: Teach the subjects included in the seventy-five per cent. group by means of those included in the twenty-five per cent. group, using the latter as tools.

I would like to add to what Dean Thornton has said, that in our experience of those who fail, practically all fail through some defect in the human or character side, and not through lack of technical ability.

In Dr. Mann's closing remarks, he inferred rather pointedly that the student's difficulty lies in his inability to see some tangible meaning to the theory he is studying. Perhaps an example will throw light on the subject.

Some eight years ago we established class instruction in shop problems for our trade apprentices. These boys had left the public school, as thoroughly disgusted with public school life as any boys could be; within three weeks they were carrying problems home with them and working them out with astonishing enthusiasm. These problems dealt with the things of their daily work and then we always gave the problem first and the method of solution afterward. A simple illustration: The value of π must be learned some time. Up to that time the boy has been figuring volumes of rectangular form. One morning he is confronted by a straight-sided round bottom can. The problem is, How much transformer oil will the can hold? Very suddenly he finds he must know the relation between circular and square areas. With wooden discs of various sizes and a steel tape he begins to find this mysterious relation of circumference to diameter and under the guidance of the teacher he works out his conception of π —not because π is worth anything under heaven, but because it is necessary to get the amount of oil that can will hold.

The same thing is done in percentage and proportion. All the book rules on proportion are absolutely useless when the boy once gets the fundamental principle. There is no such thing as compound proportion. Such problems are merely simple proportion repeated for each separate condition. There is no need for compound interest, for such problems are merely simple interest repeated with a new principal. In all problems the method has been a mere incident, a necessary tool to use to get a result which is generally recognized as a vital part of some man's job.

Some one has spoken about records. Instead of keeping them in guarded books, we post them on the walls or in open books. We have 350 trade apprentice boys, and 150 college graduates and everyone's record is open to public. We have yet to find the first disgruntled feeling. On the other hand, there is a very decided degree of enthusiasm over maintaining high records.

I would like to give you a few figures, to add to Dr. Mann's report. We visit the technical schools of the country every year. In 1915 the schools of electrical engineering graduated, roughly, 1600 men. We visited sixty-five of these schools, and interviewed (one man at a time) over 600 of these men. We labelled a little less than one third of them as men we would be willing to take chances on. Or to put it another way, 400 of them (25 per cent. of the total) did not qualify. I am sure, too, that you would pass the same judgment that we did. I can give you a hint at the reason. Every single one of those we were doubtful about, failed to impress us as a man of power to do things. In many instances where we had a chance to give this information to the candidates and the reply comes back to us, "I wish to goodness somebody had told me that, years ago. I did not know I would be judged by such things."

We had over a thousand employees attending The Casino Technical Night School last winter. The night school teachers have been picked from the rank and file of employees; but they are all men who are especially able in their particular subjects. Not a single one is a trained teacher. They know little of the theory of teaching but by their intimate knowledge of the actual work and their interest in helping young men along they are well qualified for the job. They know the daily problems of the boys because they live and work with them. They have sympathy for the students. The teachers are not handicapped by a lot of poor students. A student whose grandmother sends him to school isn't there. We have only the live ones.

The enthusiasm and interest are great; the amount of work done by both students and teachers is really phenomenal. Those of you who teach in night schools know that the teacher is not burdened by any discipline; it is not necessary for him to make any effort to keep the students keyed up. His burden is to keep up with the students.

We do use some academic textbooks; but the teachers supplement these a great deal because they actually know factory life. A fellow is given a lever, some weights and a piece of string, and asked some questions. It is perfectly ridiculous to call levers first-class, second-class and third-class, as though one is not as respectable as another. They are all alike. And it is perfectly ridiculous to teach percentage, and then interest, and then bank discount and then brokerage. The fundamental principle is the thing; and it is the same in all these. In our whole scheme, clear through, the fundamental idea is to teach men to think. That has been the steady objective; and we use all the technical terms of the profession simply as tools to accomplish this purpose—to develop in the student's brain the power to handle himself under new and changing conditions and to make a really strong man of him. Whether this is done in medicine, or chemistry, or astronomy is of small consequence in the mental training process. We train him to apply the information we give him through original independent thinking.

Professor Jacoby: The chair would like to express on behalf of the Society the appreciation which I believe we all feel of the presence of men such as Mr. Dooley at our meetings.

Mr. Dooley: Thank you very much. I am glad to be here and contribute my little part for what it is worth.

Dean A. H. Fuller: I should like to tell you about the experience of one of our men in teaching geometry in the high school. He uses no text. Every problem is an "original." I know he has had those youngsters interested. I think he has been teaching geometry at the same time. It suggests the possibility of teaching youngsters how to think and think straight, by getting at them in the right manner.

President C. S. Howe: Dr. Mann's report has given us some constructive suggestions which we shall all study very carefully when we have the written report, and which I believe we shall be obliged to put into practice. I do not wish to discuss them here. I wish to say just one word regarding the characteristics of an engineer, as defined by engineers themselves.

We who are teachers know that the things we teach our students are a very small part of their education. We know that perfectly well. It is evident that the engineers think so, too. They have assigned only twenty-five per cent. to the things we teach.

But I have noticed this: I have talked to a great many employers of engineering graduates, asking them for criticisms of the men we turn over to them; and the only criticism they make of the men is that they can't do anything. I have never heard them mention one of the characteristics they have written to Dr. Mann about, with the exception of judgment. I think I have heard two men speak of that; but all the rest criticized the lack of the ability to do things.

I cannot quite understand why, with this criticism which is coming to us all the time, they should place *ability* last in the list they have given to Dr. Mann; except on the ground that in answering Dr. Mann's question they have carefully considered the problem, and have placed their real views before him, whereas in answering my questions they have done so off-hand, and have not given the proper amount of consideration to the subject. I believe they are wrong when they tell me that the one thing they would criticize, or the most important thing, is the lack of ability to do things; and they are right when they write to Dr. Mann that the characteristics which an engineering graduate should have are character, initiative, judgment, and the rest.

We should remember, however, in connection with this, that a young boy just out of college cannot be expected to have a great deal of sound judgment. He is going to have that as he grows older: he will acquire it in his practice. He does not acquire such things wholly in his engineering course. He is too young, too immature, to have very sound judgment in regard to engineering problems.

Another thing I would like to suggest is that notwithstanding the figures given us with regard to the men who have failed, we all know that quite often men who do not pass with very high marks make very successful engineers.

Professor D. C. Jackson: After having watched the career of many young engineering graduates, I have come to the conclusion that a large proportion of those who do not do well fail on account of their personal characteristics.

One of these is perhaps the characteristic of "freshness," which leads them to do things which they are told to do but without following their instructions or without listening carefully to those instructions. Another is what I will designate "mental courage" which is that capacity which enables a man upon having failed one time to undertake again to do the same thing and succeed; or perhaps trying the third and fourth times before succeeding; and also it enables him to undertake a thing which he has not done before, and do it right. Another type of failure I ascribe to the lack of ambition—some call it laziness.

These three are all characteristics which pertain to the word "character" I suppose; so I presume these failures would be ascribed to lack of character. Experience shows positively that freshness can be reduced and even eliminated from the youth by properly teaching him the subjects we normally deal with in the engineering schools. Mental courage can be improved, if not actually put into a man by the instruction in the laboratory. So far as the third factor is concerned, the factor of ambition, I am quite sure that a good many young men are taught the joys of accomplishment in the engineering schools; and that is all that is necessary to put their ambition on its feet. By such treatment a good deal of the problem of Dr. Mann's seventy-five per cent. may be solved by our regular curricula. It is but necessary to add to our ordinary teaching a consideration of the individual characteristics of each student.

Mr. A. L. Rohrer: The word which I have to give is spoken from the standpoint of an employer of the young engineer. I appreciate very much this interesting study that Dr. Mann is making for us, and it must be very helpful in solving the problems of engineering education. It would not be in good form for me, a mere layman, to suggest to you educators any particular way in which your teaching methods might be improved. We all know that when we are dealing with the concrete there is always great zest on the part of the young man, and no doubt some of you bring into your classrooms many of your consulting problems and have seen how anxious the young men are to have a hand in solving them. I am much interested in the discussion of personal characteristics. Dr. Mann has shown us by his data how important it is to give it attention, and I know of one university where they are doing it in a very systematic manner, with the result that some of the undesirable characteristics are being eliminated by the students.

The question has been asked here as to the cause of failure of some of the young engineers. In my experience (which covers some five or six thousand young men) we have had a few failures due to lack of technical ability, but the worst failures, and the majority of them, resulted from a lack of these pleasant personal characteristics which are so helpful to success. I would suggest that all of you discuss this with your students in a definite way, first in your classrooms and then with the individual; and if done in the right way and at the right time, you have done something towards keeping him from failure in the future. I have enjoyed these discussions very much and feel well repaid for the time I have taken from my office to attend these sessions.

Professor James R. Withrow: The first questionnaire sent out by Dr. Mann could only be expected to be qualitative in its results because it was unlikely that the engineers replying should think of all the topics suggested by other engineers and voted upon in the replies. These men were to *suggest* quite independently, topics of importance from the point of view being considered and also list them in the order of their importance; in other words, they were to both nominate and vote upon them. The results of the last questionnaire were more nearly quantitative because the Foundation averaged the former replies, selected the topics to be voted upon and requested a vote by the profession. It is interesting to note, however, that there is a striking tendency toward agreement, in the two votes, even from a quantitative viewpoint, as Dr. Mann has pointed out. In discovering this general quantitative agreement the Carnegie Foundation, through Dr. Mann, has made definite progress during the past year in crystallizing into a rather definite ideal the opinion of the members of the engineering profession with reference to what qualities make for engineering success or are of greatest importance in sizing up young men for employment or promotion, and it is to be hoped that the report will be distributed broadcast among engineers.

Such a report will assist teachers, while laying broad, scientific and technical foundations, to keep before them the fact that they should be constantly developing and keeping in mind the paramount importance of:

(1) Character,
(2) Judgment and resourcefulness,
(3) Initiative and efficiency,
(4) Understanding of men.

Dr. Mann's suggestions on the latter subject, human engineering, are very timely and should receive increased attention from teachers and the profession. The recent Congress on Human Engineering at The Ohio State University should be followed at other institutions by similar organized efforts at mutual understanding along this line.

In the list of qualities necessary for success, etc., I believe resourcefulness is a result of experience, and therefore I should prefer to place it in the group with judgment rather than with character and integrity. Initiative is closely related to efficiency and I would head *this* group, therefore, the "Initiative and Efficiency Group," rather than place initiative in the character-integrity group.

We should not fail to ponder on the importance of Dr. Mann's statement that growth in the four qualities mentioned above cannot profitably be arrested for four years *even to obtain a more thorough technical training* and that much more efficient is the teaching of technology which gives opportunity to develop integrity, initiative, resourcefulness and common sense as well as technique. It is true that one has little opportunity of displaying these vital qualities in his profession until he *has* become an engineer, that is, has displayed technical ability. However, *we* must not put technical training first but develop our work, or even slow up if necessary in our technical teaching, to insure the student a growth in the character group of qualities. We cannot afford to navigate without possessing *all* of these qualities which were voted upon. He is obviously a poorly developed and "one-sided" engineer who lacks even the quality with the lowest vote value. Our technical training therefore must be *based on* or involve efficient training in this character-judgment-efficiency-humanity direction (not "humanities").

I imagine most, if not all, of our science and engineering subjects are admirably fitted for such treatment, and may readily become the vehicle for developing these desired qualities so necessary for professional as well as personal success. It becomes strongly evident that the dominant feature, in discussing ideals and successful engineering training therefore, is the teacher himself as a man. The teacher's point of view and attitude toward the utilization of his subject for consciously developing these qualities becomes of prime importance. In addition it must not be forgotten in discussing the "what" and "how" of teaching that a good teacher often obtains results by methods that are useless to even other good teachers and I believe these ideals now laid down will act as a stimulus and a help to all teachers, be their methods whatever they may.

Having apparently ascertained that the real problem of the schools is to meet the ideal laid down in this report, the report becomes a lamp in whose light the schools of engineering may judge their own work and map out their progress and keep clearly in view the goal toward which they must ever work. The question then arises, how may this goal be most closely approached and how must our fundamental technical teaching be arranged and conducted? These are the questions in which we were all originally interested but we now have a tool for measurement.

In this connection I believe that as teachers, we can profit by the profession's discussion of the "how" and "what" in teaching, before discussion by the teachers themselves, who after all must decide the matter though they should not do so arbitrarily. I hope that the Joint Committee will not neglect this help from the profession and I believe our courtesy will be appreciated by the profession.

While Dr. Mann, I believe, has been good enough to point out that the technical subjects in the engineering schools appear to be well handled, yet there is much still to be desired in engineering education. For instance in studying statistics collected by Dean Coddington of the college of engineering of The Ohio State University when he was secretary of that college, in the matter of the grades obtained by students in engineering throughout their four years, their curves appeared distressingly as though the engineering college work was an *indurance contest* and not a *development,* as I surmise education should be.

In Dr. Mann's report, the test conducted on freshman engineering students is really a test of the product of the high schools and most of the questions were apparently directed at the memory faculty. Some are aimed at knowledge of a particular ancient definition. For instance "A body of — entirely surrounded by — is called an —." If the student had had a teacher who emphasized that all land was entirely surrounded by water and that the smaller portions detached from the mainland or continents were called islands, this pupil would have a real problem on his hands to fill in the desired spaces in the above question.

The first year student who could find his way through the paragraph beginning "A chief characteristic of science," etc., under the head of "*English,*" and understand the appended questions, should in my opinion receive a diploma forthwith. It is likely he would be spoiled by an engineering course. It is to be earnestly hoped that no teacher of engineering will feel at liberty to make this paragraph and its questions his ideal for clearness.

The question in "physics" regarding the amount of water which "must be added to a pint of alcohol 95 per cent. pure to make a solution of alcohol 40 per cent. pure," cannot be answered from the data given. The statement that Professor Thorndike found that "only one third" of his 220 engineering freshmen could solve the problem is interesting. It recalls the inattentive student who was asked the cause of the aurora and attempted to excuse himself by stating that he "did know but had forgotten." Whereupon the professor said "How unfortunate! The only man who ever knew has forgotten."

It is probably intended by the question to develop the idea that one pint of 95 per cent. alcohol contains $^{95}/_{100}$ pints of real alcohol and that each pint of 40 per cent. alcohol contains $^{40}/_{100}$ pints of real alcohol, therefore, one pint of $^{95}/_{100}$ pure alcohol *will make* $^{95}/_{100}/^{40}/_{190}$ or 2 and $^{15}/_{40}$ pints of 40 per cent. alcohol. It would not follow, however, even if this were true, which is doubtful, that 2 and $^{15}/_{40}$ pints minus 1 pint (95 per cent. alcohol) equals 1 and $^{15}/_{40}$ pints of water *to be added* to get 40 per cent. alcohol, from the one pint of 95 per cent. alcohol. *This will not be enough water,* for the mixture shrinks in volume. The resulting alcohol would be *over* 40 per cent. strong. Because of ignoring the inherent volume change, the strength of the resulting alcohol will be in error 2.5 per cent. by volume or 3.0 per cent. by weight, a very grave error for scientific or engineering work.

The apparent object of the question to get at the true significance of "per cent." is commendable but *chemical* questions should not be made the basis for such a demonstration because they frequently, as in this case, teach the students false fundamental chemical ideas. In some cases which might have been selected the error due to the ignored volume change could have been much larger.

Such problems are too frequently used, thus not only missing the opportunity of calling attention to the fact that because of the volume change more data is necessary than would be expected, but still worse, the fact that such a problem is given at all (in the absence of discussion of the facts) operates to impress the student *that he has been informed* that chemical compounds like alcohol and water can be mixed to obtain a final volume equal to the sum of their respective volumes, a very dangerous mental attitude, and one which would result disastrously for the chemical engineer. For instance if this problem had furnished the specific gravity of water and 95 per cent. alcohol and requested the specific gravity of the resulting mixture the calculated specific gravity would have been about 16 per cent. away from that of 40 per cent. alcohol. In order to avoid these difficulties the problem should have stated the weight of a pint of water and also of the respective strengths of alcohol or their specific gravities.

Serious consideration should be given to the suggestions made by Dr. Mann in regard to increasing student efficiency, and it is to be hoped that Dr. Mann will be able to suggest some particular way for carrying out these ideas. It is one of the greatest problems of teaching to cause the student who has the tendency ''to soldier'' to take an earnest hold of his work. It also is a problem, though not very common, to prevent the student who ranks high in his class from acquiring the proverbial ''big head'' which makes him so unsatisfactory to his fellow students and subsequent employers. Although such a student usually gets along in spite of this failing, he nevertheless has a discouraging influence on the desire of other students to stand well in their work. It is a little difficult to see how the ideas which Mr. Taylor has been able to work out in the industries can be applied to the radically different subject of teaching. Mr. Taylor's ideas were not applied as such to the sole part of industrial work which involves the teaching of methods or operations. It is probably not intended by Dr. Mann that scientific care in the setting of problems before students is not exercised at the present time in the colleges, for most teachers at least of technical subjects undoubtedly give this matter serious and careful attention and many of them have very gratifying results. We must not forget, also, that the large portion of the student's work is of the nature of drill. This being the case it is hard to see how in all classes the tasks of the students can be arranged from easy to difficult though naturally every teacher arranges his work, as far as possible, in this way, otherwise, the student takes little interest in his work.

It will be noticed from Dr. Mann's discussion that in the industries great pains are taken to see that each workman is carefully instructed in the most efficient methods of doing his work. I do not believe that as a rule in the colleges much effort is put forth by our institutions in teaching our students how to study and yet most all teachers agree that they do not know how. It seems as though some method should be arranged whereby we should have more extensive application of the idea which I understand is used at some institutions of taking the entering student and giving him explicit instructions in the proper methods of studying the work which he is to undertake. This matter I think cannot be emphasized too strongly by Dr. Mann. There are great difficulties in the way of doing this thing but any effort made would surely be worth all that it would cost.

Some of the illustrations as given by Dr. Mann of the interest aroused in certain work are not very clear. For instance, when it is stated that freshmen in chemistry are given problems in one school very similar to those given in other schools to *seniors* in chemical engineering it is hard to understand just what is meant. It is, of course, a fact that in giving work to advanced students we are compelled to incidentally use means which even freshmen can undoubtedly handle. They can all spell and they can all count or figure, they can all use the fundamentals of the science when they are seniors, at least they should be able to, but it would be unfortunate if the impression got about that because the freshman can also do this that they are doing the work of seniors in chemical engineering. It is obviously impossible for any freshman to do the work which is the real work being carried out by seniors in any real chemical engineering course. In the first place they have not yet had the chemistry and in the next place they have not yet had the engineering, and so obviously such statements are subject to misconstruction though they doubtless have relation to some foundation idea. It is perfectly true, for instance, that a freshman in chemistry may be asked in making anything to figure out how much it cost *him* to make it so that he may be doing some work which a senior also may do, but while manufacturing cost calculation is properly part of the work of advanced students in chemical engineering it is only a very small portion of their work though an important portion. In any event it is a matter which no freshman can adequately elaborate for the reason that he has not had enough of the fundamental or advanced work in either chemistry or engineering. He can only handle the matter in a general fashion and the result will be, that if an effort is made to go into such matters in anything but the most superficial manner that valuable fundamental material must be left out for lack of time and when the man reaches his advanced work the instructor here will be handicapped by the constant necessity for teaching fundamental work which should have been taken in the first year and the student may get false ideas of the commercial value of his results. However, I believe in utilizing anything in the teaching of fundamentals that can bring better results, always, however, calling attention carefully to the fact that exhaustive or technical treatment is not intended. I agree very thoroughly with Dr. Mann in his objection to the presentation of any work in an abstract manner. The presentation of mathematical or chemical puzzles to students when concrete cases can be given is not the way to teach any science, in my opinion.

Professor Sperr in the discussion has called attention to a matter with which I am in hearty accord when he emphasizes to what extent it is the teacher's business to reduce, as far as possible, the percentage of failures in his classes. It is too often a matter of pride among teachers that their course is so stiff that only select material can succeed in passing it or that it is reputed to be a difficult course. It should rather be the teacher's pride that he has been able to help students rather than rule them out. Any method, such as Professor Sperr seems to have pursued, which the teacher can devise to this end, makes him an increased benefit to the community which it is his duty to serve, as well as to the individuals who come under his care and whose future is to a considerable extent in his hands.

Dean Cory in the discussion has called attention to the method used at his institution for saving students who showed backwardness from any cause, by interviewing them at the end of six weeks' periods. This method I can heartily commend because it sounds similar to the one that was applied to myself as a student at the University of Pennsylvania twenty-two years ago, with very satisfactory results from the student's point of view. Even tendencies which in time would result fatally to the student can be detected and eliminated by such personal touch. Dean Cory has also called attention to the necessity from time to time of checking up the character of the work itself which is being given to the students. This is frequently of assistance to the teacher as he is apt in the strain under which he works to acquire a biased or improper attitude towards even his own work and it does not pay him to be unfair to the student and the sooner he learns of it the better for all concerned.

Dr. Mann in the discussion suggests that the fact, that technical subjects appear more efficiently taught than the theoretical ones, is probably not because the technical men are better instructors or better masters of pedagogy, but because they are in more immediate touch with real things and the student gets a conception of the fact that the problem is real. Without question this situation helps much in the teaching of technical subjects. We must not overlook the fact, however, that these teachers of technical subjects have an additional advantage over most of the teachers of theoretical ones—an advantage, however, which these teachers could largely overcome if they cared to. This advantage consists in the fact that the man who is used to the responsibility of commercial problems which must be solved and solved at once, in other words, who is confronted with the proposition of being compelled *to get results,* will naturally have a different attitude towards his teaching of any subject and will go at it in a different way and more from the point of view of vital fundamentals, than a teacher of any other experience can do, though these other teachers may acquire ability to a varying extent in this same line if they choose. So that the point of view and mental attitude of teachers in technical subjects is usually quite a different one from that of other teachers, even though they happen to be excellent teachers of subjects where these teachers are not themselves forced to handle their problems in a business like way. This is an advantage in attitude which all teachers should aim to possess if they can secure it and I believe it can be secured if the will exists. Mr. Dooley in the discussion has called attention to the success he has had in his technical night school, where the teachers are not trained ones and who do not know the theory of teaching. As he says, by their intimate knowledge of the actual work and their interest in helping young men along, they are well qualified for the job. It should be noted in addition that they are men who are used to commercial responsibility, to being called upon to meet situations and to bring results, and at once, if possible. This, in my opinion, will make any informed man of breadth of view a good teacher if he is interested in teaching. If we are engaged in research it helps our teaching ability, but teachers may be engaged in research which is merely an interesting problem which can be taken up and laid down at pleasure and which never needs to be completed except we have the inclination to do so. In other words, we are never held to an account. No pressure except our own good pleasure is brought to bear upon us for results. Such work is certainly much better than no research work at all, but it lacks the training to the teacher himself of work which involves responsibility and must be done in a specified time or under pressure.

I am not competent to discuss the experiment on mechanics in the first year which Dr. Mann has mentioned, but it sounds very interesting and I hope will be successful. We must beware, however, of drawing general conclusions from educational experiments which may be very attractive or successful because of the personal enthusiasm of their inventor. This is one thing which makes education so complex. Frequently a method which is very successful in the hands of an enthusiast for that particular method may bring little results from the hands of some one else who is not so enthusiastic regarding the method but who may be just as enthusiastic in the science or subject. In other words, we must not be misled by isolated experiments.

With regard to Dr. Mann's question, "How shall we make the engineer more cultured?" that is a matter upon which I would like to see discussion, first, from the point of view of "What is culture?" and second. "In what way our science and technical subjects lack it." My understanding of culture is one thing, and perhaps others have another idea. I do not believe myself that any man leaves any university cultured, though he may be given a point of view which may enable him to acquire that state. I believe we can do much in the schools to develop the human side of the man and I am greatly surprised if in the technical sides of education. at least, much is not now being done in this direction, as well as giving the student a mastery over matter. I have the idea that technical subjects can be intensely human.

Dean A. A. Potter: Regarding the relation between good scholarship and success in life, the members of the Society may be interested in an investigation carried on by William T. Foster, of Reed College. Mr. Foster examined the records of 17.000 alumni from Harvard and Yale, and found that the probable chance for success of the good student as compared with that of the mediocre student was in the ratio of about 12 to 1.

Dr. Mann: It must be fairly clear to everybody here that this is a very complicated problem and that it is impossible for us to make each other understand what respective points of view are, even in so interesting and lively a discussion as we have had tonight. There has been a great deal of misunderstanding of what was meant by that card sent to the engineers, and by the summary of the answers received. There is a great deal of misunderstanding about the percentages which have been attached to indicate the relative values of the several factors.

There is, however, one point in the investigation which is as simple and as universally accepted as anything we have in this world, and which every one here tonight has mentioned—namely, that there are other things in life that are at least as important as knowledge. It makes little difference whether you say seventy-five and twenty-five; or ninety and ten; or how you number them. There are other things in life that are just as important as knowledge; and that old saying, ''Knowledge is power,'' is not necessarily valid for school work. This is the whole point, and it is very, very simple. A great many engineers have been asked to express their opinions concerning it for the sake of emphasizing a thing that Adam must have understood, because we have forgotten it in our school work. We have forgotten it; and it is necessary to recall that pre-Adamic fact.

It is perhaps fortunate and very appropriate, that this particular discussion of this subject should take place at this Institution—the University of Virginia—because it must be clear to all of you, even after so short a visit here, that there are a great many things about this Institution besides the daily work in the classroom that make for those personal characteristics that have been evaluated at seventy-five per cent. This institution is preëminently noted for its emphasis of the human side of the student work. Perhaps it presages a greater emphasis upon these things that make for character, such as student traditions, university traditions, and enthusiasm for work, to have this meeting at which this point is emphasized, take place here.

This question of engineering is much more difficult than the problem of the law school and the medical school, because the engineer has to deal in his profession with material things, mainly. It is much more difficult to master matter, than it is to exploit mind. Also, the mastery of matter, if one becomes entirely absorbed in it, is apt to so overwhelm us with its difficulty that we forget sometimes that there are human qualities which also must be developed. One of the marked criticisms has been made of the engineer by the professional man and others—one of the big problems before the engineering world today—is the question of how we are going to make the engineer a cultured gentleman, in the good sense of that word. How are we going to develop the human side of the engineer, as well as his technical ability? This refers not only to character but also to what is generally called culture. How are we going to add that to the technical knowledge of the engineer? This is not an easy problem, because we have been brought up—as I showed you, our school system started in from the beginning, in 1642—with the ruling out of vocational training from the rest of the system. Thus a gulf was introduced between learning to earn and cultural study, and that gulf has remained from the very beginning and is still there. How are we going to get rid of it? How are we going to unite the training for the mastery of matter with cultural work, so that they will make a harmonious whole?

That is, after all, but another way of stating the real problem. So I would like to leave the problem in that form in your minds. That is: Vocational education was separated from cultural education at the beginning of our school system: How are we going to get them together? The men devoted to academic education realize that, as Lincoln put it, their legs are not long enough to reach the ground, and the men in engineering realize that there are regions above the region of matter which they have not yet fully entered. How are we going to get the two kinds of training together?

Professor Kent: Show us a reason why we should get them together. Culture is on the defensive now.

Dr. Mann: Again this illustrates the difficulty of making yourself understood. I see that Mr. Kent and I are using the word "culture" in different senses. I might ask Mr. Kent to tell me what is the meaning of the word "gentleman."

Professor Kent: My meaning is quite different from others, perhaps.

Dr. Mann: Well, that is just the point. This is another way of stating the thing we have been discussing all the evening. How are we going to develop the human side of the man while we are training him to a mastery of matter? I ask you not to form too hasty a conclusion that the figures that have been presented are all wrong—that there is nothing in it—because there is something in it. Progress may be slow, but the problem is to develop technical ability and human qualities simultaneously. Is this right?

REPORT OF JOINT COMMITTEE ON CLASSIFICATION OF COLLEGES.

Committee No. 6.

BY C. S. HOWE.

The Committee of which I am a member has had no meetings this year, and hence has no report to make. I might say a word in regard to the formation of that Committee. It is made up of representatives of different educational bodies, appointed at the request of the United States Commissioner of Education. More than a year ago we had a meeting, and suggested a list of questions which should be sent to educational institutions. It was decided to send out first a list for the academic colleges, and afterwards to prepare questions to be submitted to the engineering colleges and other institutions. The questions for the academic colleges have been prepared during the past year, and have been sent out. The Commissioner, or rather the specialist in higher education, Dr. Capen, wishes to study the answers which are coming in from the academic colleges before taking up those for the engineering colleges. That is all I wish to say, except that the Committee deserves the thanks of the Society because it has not sent out any questionnaires during the year.

REPORT OF INSTITUTIONAL COMMITTEE.

COMMITTEE NO. 7.

BY G. R. CHATBURN.

During the year two circular letters have been sent out to the members of this Committee, bringing before them such matters as had been referred to the Committee by the general officers of the Society, and some other matters which had been brought up by the members themselves. After receiving replies from these letters, we made a tentative report, which was compiled and brought before the Committee this morning. Most of it was adopted. A part has yet to be acted upon.

First, in regard to the policy of the Society concerning institutional delegates, the Institutional Committee respectfully recommends that the following be adopted as the policy of the Society:

1. At least six weeks prior to the annual meeting the Secretary shall send to each institution holding membership a request for the appointment of a delegate, if practicable, from the persons of the faculty who are members of this Society, or from its administrative staff.

2. The names of institutional delegates shall be published in the Year Book in connection with the names of the institutions.

3. Three copies of the publications of the Society shall be sent to the institution, and not to the delegate.

4. Non-member delegates will not be required to pay dues.

5. Regular members who act as institutional delegates are not thereby relieved from the payment of dues.

A suggestion was made to change the personnel of the Committee. This change was voted down at a meeting this morning, and the personnel therefore remains as it was last year, which is as follows:

"The delegates in attendance at any meeting shall continue as members of the committee for one year thereafter or until their successors have been appointed by the heads of their respective institutions."

The question of the purposes of institutional membership was referred this morning to a subcommittee. This subcommittee has already met and prepared a change in the statement as made in the preliminary report, with some additions. This will be reported when acted upon by the whole committee.

The Institutional Committee further recommends that the following be adopted as a statement of the duties of the institutional delegate:

Before the Annual Meeting.

To familiarize himself with the needs and desires of his own institution.

To familiarize himself with new methods and practices in his own institution.

To have these prepared for presentation to this Society.

To bring before his own faculty, and especially the local members of the Society, questions of policy and interest to the general Society.

During the Annual Meeting.

To observe carefully the program and take note of those reports, papers and discussions of interest to his own institution.

To attend the meetings of institutional delegates.

To present to the Society pertinent ideas and practices of members of his own faculty.

To ascertain through conversation and otherwise the practices of other institutions regarding questions under discussion during the year in his own.

To extend his acquaintanceship and note especially the personality of men available for positions in his own institution.

To represent generally his own institution by looking after its interests whatever they may be and whenever and wherever deemed necessary.

After the Annual Meeting.

To make a brief report to the administration of his institution, touching in a general manner the most salient features of the convention.

To make at the opening of the fall term a more detailed report to his engineering faculty at a meeting called for that purpose.

To represent during the school year following the annual meeting the general Society in his own institution.

To furnish news items, or procure someone else to furnish them, to the *Bulletin*.

To bring the general Society as fully as possible before the faculty of his institution.

To encourage members to attend the annual meeting by bringing back to them its enthusiasm and showing them the advantages, both to themselves and the institution, of attendance.

Discussion.

Dean C. H. Crouch: (By letter). In discussing the recommendations of the Institutional Committee I would first call attention to the importance of sending out the requests to the institutions holding membership asking them to appoint delegates in ample time so that the delegates appointed will have sufficient time in which to formulate their plans so that they may be able to attend the meetings. It may be that the presidents of the institutions will delay acting until the faculty members have arranged for their summer vacations, but if notices are sent out six weeks in advance it will not be the fault of the Society if they are not appointed until a few days prior to the meeting.

It seems to the writer that if an institution pays a membership fee of $10.00 per year, that it should be allowed to be represented at the meeting without its delegate being obliged to pay an additional fee as a delegate unless such delegate is a member of the Society.

I do *not* believe, however, that because a member is appointed as an institutional delegate he should be excused from paying his regular annual fee. I regard his appointment as an institutional delegate as an institution affair rather than as a Society affair and believe that all members should pay their regular annual fees whether institutional delegates or not.

As to the remainder of the report of the Committee dealing with the purpose of the institutional membership and the duties of the delegates, I believe the report will meet with the approval of all, especially the third and last paragraphs dealing with the purposes of the membership, and will, therefore, not comment further.

REPORT OF COMMITTEE ON ENTRANCE REQUIREMENTS.

Committee No. 8.

BY C. M. WIRICK.

Your Committee on Entrance Requirements herewith presents the following report:

At the Pittsburgh meeting of this Society which was held in 1910, your Committee on Entrance Requirements presented a report outlining a rather comprehensive list of subjects which it was thought would satisfy the scheme of study for secondary schools and at the same time would be suitable for entrance to any engineering college. Formulations were given and the content of each subject was defined. Recommendations were made that this Society use its influence to the end that the required subjects be reduced to 7 or 8 Carnegie units and that the remaining 7 or 8 units be selected from a suggested list of subjects which offered a fairly wide range of electives. The aim of this Committee from its inception has been the elimination of the multiplicity of subjects formerly required for admission to the various engineering colleges of the country, and the acceptance on the part of the members of this Society of a relatively small and comprehensive group of subjects from which the requirements for admission to any college might be restricted. It was early recognized that absolute uniformity is inconsistent with the diversity of educational conditions in different states and is neither possible nor desirable. But, as pointed out in a previous report (Vol. IV), needless arbitrary deviations from uniformity in mere details are vexatious and harmful to all concerned, and should be removed. Various agencies have been active in bringing about a greater degree of uniformity in entrance requirements and the purpose of the present report is to show the existing status of entrance requirements for engineering colleges and note the trend of the changes that have taken place during the last few years.

To this end the following questionnaire was submitted to the various institutions represented in the Society:

1. What changes, if any, have been made in the entrance requirements to your institution since the 1910 report was submitted to the Society?

2. What suggestions, if any, have you to make regarding entrance requirements? The replies received indicate clearly that the 1910 report of this Committee is not available to a large proportion of the members of the Society; therefore, in order to obtain an intelligent comprehension of the present status and trend in entrance requirements it will be necessary to review briefly the 1910 report. In that report it was shown that a unit course or credit required for entrance is to be understood as representing work equivalent to that covered in a school year of thirty-six weeks, five periods per week. each period not less than forty minutes in the clear; this includes an aggregate of one hundred and twenty 60-minute hours of class-room work. It is further understood that two periods of laboratory, or manual training (including drawing) is equivalent to one period of class-room work.

Following the standard established by the Carnegie Foundation for the Advancement of Teaching it is recommended that fourteen units constitute the minimum amount of preparation which may be accepted for entrance.

If in the aggregate four studies be pursued each year for a period of four years, it will be possible to qualify in sixteen units; a unit, therefore, constitutes practically one fourth of a year's work.

The selection of subjects which will be accepted for entrance should be to a certain extent left to the individual colleges. but there exists a marked tendency toward uniformity of requirement with certain studies and a fair degree of freedom regarding the remainder of the subjects.

In the report of this Committee presented in 1896, it was shown that not less than 100 different requirements in subjects and content were demanded or could be offered for admission to the 89 institutions represented in the census taken at that time. In view of this diversity of requirement and with the hope of securing such degree of uniformity as would be practicable, the Committee recommended the following subjects from which the entrance requirements were to be selected:

Mathematics.

Arithmetic (complete),
Algebra, elementary,
Algebra, through quadratics,
Algebra, advanced (intermediate),
Geometry, plane,
Geometry, solid,
Trigonometry, plane.

Science.

Botany,
Physical geography,
Chemistry,
Physics.

Language.

English,
French,
German,
Latin.

General.

Freehand drawing,
United States history,
Some second subject in history.

The diversity crept in, no doubt, through the attempt on the part of the colleges to meet the varying courses of the contributory schools through a system of options in requirements, and possibly, to make the scientific courses level up to the classical ones without the necessity of imposing the dead languages on the student. But the effect was to scatter and produce confusion on the one hand and to limit each college to its own field of cultivated schools on the other.

The report states further: "There is enough within the list recommended by the Committee that so many colleges agree upon, to fully occupy the time of any boy in his four years in high school, and there is variety enough to give breadth of training. There is work in the five chief lines of mathematics, language and literature, history, science and art. Any school course, on the one hand, and any college set of requirements, on the other, ought to include all of these lines.

"Again, while the colleges should confine themselves to the above subjects there is nothing in the list that does not properly fit into the school curriculum. Laboratory work of the right kind in physics, chemistry and botany may be found in comparatively few schools, but it ought to be given in all high schools with four-year courses, for their own sakes, irrespective of the demands of scientific colleges.

"Somewhat apart from the other subjects named, stands manual training, including shop work and mechanical drawing.

"It is obviously impossible—even if desirable—to make either of these a requirement for admission to engineering colleges generally. On the other hand, the engineering colleges should be the first to recognize the true value of hand and eye work as a form of education. The Committee believes that, as far as practicable, *such recognition should be more generally shown by the acceptance of certified work in manual training as optional requirement by institutions accepting any optional subjects.*"

In the 1910 report it was shown that with few exceptions the list of subjects proposed in the earlier report included the essential requirements now accepted for admission to most of the technical colleges of the country. There has been a marked coöperation between the colleges and secondary schools which has tended toward the establishment of certain standards, both in the kind and character of subjects taught. Of the fourteen or fifteen units required for admission the colleges have demanded preparation in definite prescribed subjects amounting to about one half the total work, while the remainder may be selected from a list sufficiently comprehensive to allow the secondary schools considerable freedom in establishing their courses. Nor does this detract from the intellectual development of those in the secondary schools who do not enter college, since there is general agreement as to the value of the prescribed courses in any scheme of secondary education.

Referring to the list quoted above it will be noted that arithmetic is not, in general, now accepted as an entrance subject; on the other hand, on account of the commercial interests of the United States there has grown up a demand for the study of Spanish in the public schools and this subject should be added to the language group.

Zoölogy is frequently studied in the secondary schools instead of botany, and this subject should be included in the science group.

In many well-organized secondary schools the study of history is pursued for the entire four years and the general group should be modified by adding the four history subjects most commonly taught, or preferably a new history group should be introduced. This should include ancient history; medieval and modern European history; English history; American history or American history and civil government.

The general introduction of manual training (shop work and drawing) into the secondary schools has caused a number of colleges, both academic and technical, to accept a certain amount of this work in lieu of other subjects for entrance. Shop work and mechanical drawing should, therefore, be offered in the list of electives acceptable to the engineering college.

Your Committee recognizes that there will necessarily be differences in opinion as to the amount of credit which can be accepted for entrance by the college for manual training subjects, but substantial agreement will probably exist if the credit be restricted to one unit for shop work and one unit for drawing.

However, with the credits thus restricted it must be pointed out that in order to qualify in fourteen units as specified a student taking work in manual training must either limit the amount of this work, or he must take other studies additional to the manual training subjects.

A restriction should also be placed on the language group: That is, if a language be offered for entrance two units should be presented for any one language.

The modified list of subjects presented in the report of

1910, among which are to be found the entrance requirements for engineering colleges are as follows:

Mathematics.

Algebra, elementary,
Algebra, advanced,
Geometry, plane,
Geometry, solid,
Trigonometry, plane.

Science.

Physics,
Chemistry,
Botany,
Zoology,
Physical geography.

Language.

English,
French,
German,
Spanish,
Latin.

History.

Ancient,
Modern European,
English,
American.

General.

Manual training,
Shop work,
Mechanical drawing,
Freehand drawing.

The prescribed subjects taken from the above list should include:

Algebra, elementary	one unit.
Geometry, plane	one half unit.
Algebra, advanced	one unit.
Geometry, solid	one half unit.
English	three units.
One other language	two units.
or physics or chemistry	one unit.

total prescribed subjects eight units or seven units.

The second part of the report is concerned with the definition of subjects and formulation of content with which we are not concerned at the present time. The important part of the 1910 report upon which substantial agreement was urged was the recommendation of eight units or seven units (depending upon whether a two-years' language or a one-year science subject is to be offered) as prescribed subjects; and the acceptance of the remaining units from a list including mathematics, science, language, history and manual training; which it was believed included the essentials of a sound secondary education.

It was stated that we must be moderate in our prescribed requirements and we must ask for something that will fit our students for engineering work and at the same time furnish a certain amount of culture study; then let the high schools exercise a fair degree of freedom in the choice of the remaining subjects. The schools in general are well organized but they do not always have teachers for all the different branches desired. Sometimes it is the sciences, in other cases it may be the languages that must be reduced. In such cases it may be that there is a good teacher of history. Now a student coming from such a high or other secondary school which gives a good course in history can elect four units in the history group. Other schools may not have a good teacher in history but may have excellent courses in physics and chemistry. A certain freedom of choice should, therefore, be allowed to the high schools in order that they may adapt their curricula to their particular conditions. Since we should not be too rigid in our requirements, let us agree on a group of seven or eight subjects, as indicated here, and then let the high schools fill in the other requirements from a list of electives which, however, should not be too comprehensive. With such an accepted list, provided the subjects be properly taught, a boy can prepare in any high or secondary school for any college.

Now, coming to the consideration of the present requirements: What changes have taken place recently and what is the trend in entrance requirements? Of the changes which have occurred since the 1910 report none are more significant than the "new plan" of Harvard which in a modified form has recently been adopted by Yale and Princeton. Under this plan a candidate must (1) present evidence of an approved school course of four years' duration, satisfactorily completed; and (2) he must show in four examinations that his scholarship is of a satisfactory quality. Beginning in June, 1916, the examinations for these three colleges are to be conducted by the College Entrance Examination Board and not by the individual institution. Under this new plan the college does not intend to prescribe in detail the school course of the boy who wishes to enter, either directly by naming and defining subjects, or indirectly by an elaborate system of rating the studies of a school course in points or units. On the contrary, the college accepts the judgment of a school as to a candidate's programme, subject to certain limitations. It is not necessary, therefore, for a school to fit a candidate's course to detailed definitions of subjects. Under the new plan every school maintaining the kind of course indicated will be free to work out its own system of education in its own way, subject, of course, to the general requirement. The college on its part, undertakes only to test the intellectual efficiency of the boy at the time of his graduation from school.

As applied at Harvard which has no undergraduate engineering course the candidate may present himself for examination in (*a*) English; (*b*) Latin, or, for candidates in courses leading to the degree S.B., French or German; (*c*) mathematics, physics or chemistry; and (*d*) any subject not already selected under (*b*) or (*c*) from the following list: Greek, French, German, history, mathematics, physics, chemistry.

At Yale College, Latin and mathematics are required subjects but in the Sheffield Scientific School of Yale, the four examinations will be given from the following groups: (*a*) English; (*b*) mathematics; (*c*) Latin, French, German or Spanish; (*d*) physics, chemistry, history or mechanical drawing. In any case the candidate will be admitted without conditions or not at all. Professor Corwin,* commenting on the new plan, states that the admission without conditions will eliminate a most useless and bothersome feature of freshman work.

As to the first provision—that a school record shall be submitted—this procedure has led those who object to this or to any change in the requirements and regulations of admission to say that the New Plan is but a slightly disguised plan of admission by certificate. It has, to be sure, one characteristic of the certificate plan—the school record—but while saving the most important quality of the plan of admission by certificate—that is, its selective function—it has remedied by the four comprehensive examinations the principal defect of that plan—that is, its inability to establish and maintain even an approximate standard of quality. A record covering four years of school work, indicating textbooks used, proportion of laboratory work, and scholarship grades obtained, will certainly give pertinent evidence of a candidate's fitness, and the comprehensive examinations which accompany it will serve both school and college as a means of maintaining the scholarship standards.

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* Chairman, Committee on Admission, Sheffield Scientific School.

The avowed purpose of the New Plan examinations is to reach out for the boy who has not been specially fitted for college, or to put it in another way, to make the preparation for college less conventional and less subservient to tradition. The new comprehensive examinations are to be adapted to such variety of school instruction as exists in the various subjects required for admission; that is, they are not to prescribe methods and are to recognize the general principle that the secondary schools shall determine how a subject shall be taught and that the college shall test for results and power.

The antithesis of these requirements is seen in the new regulations governing admission to the university and other state institutions of Kansas. At its last session the Legislature of Kansas passed a law which provided that graduates from any approved course of study in high schools of the state shall be entitled to admission to the freshman class of the university and other state institutions. This rule applies to the school of engineering. The board which has the power to approve these high school curricula includes the state superintendent of public instruction, and the presidents of the three principal state educational institutions.

It seems fitting at this time to mention the ''Chicago'' plan which has had a decided influence on the entrance requirements of western institutions during the past five years. Desiring to coöperate more effectively with the secondary school, the University of Chicago, 1911, introduced certain essential modifications into its entrance requirements. In making the changes the university had several distinct principles in mind, the more important of which may be briefly abstracted from a statement prepared by the university as follows:

"Heretofore the university has admitted students from approved schools without examination. The schools were approved on the basis of inspection by a university officer. This practice will be continued. Schools not already on this list will, at their request, be inspected and if approved, will be put upon the list. The retention of the schools upon the list will thereafter depend upon the records made by the students sent to the university from the schools. It is intended to keep the school principals accurately and frequently informed of the records made by their students. It is also contemplated that, as far as possible, representatives of the schools may from time to time come to the university and visit those classes which continue most directly the work done in the schools. It is hoped in this way to secure a more intelligent coöperation than has thitherto been possible.

"The university recognizes the obligations which the high schools are under to serve their own committees in the most efficient possible way without primary regard to college entrance requirements. It, therefore, desires to render as flexible as possible the conditions under which students may come to the university, and it proposes to set up only such requirements as seem indispensable to enable the university to continue with advantage the educational work begun in the schools. With this principle in mind, the university faculty has replaced the former schedule of requirements, designating a considerable number of specific subjects in which the student must have been prepared, with a plan which, save for a requirement in English, lays emphasis not so much upon specific subject-matter as upon a certain amount of concentrated and continuous work in subjects selected by the student, or the school from among the standard academic subjects taught in all high schools. The quantity of the work required is specified in the paragraphs which follow. The quality of the work the university expects to test by the record of the student after he comes to the university.

"It is believed that sufficient flexibility has been introduced (1) to permit the schools to meet every reasonable demand of their own communities in the arrangement of the curricula, (2) to enable the student to enter college even though he decided late in his course to do so, and, at the same time (3) to make it justifiable for the University rigidly to require of each student a full 15 units of entrance work. There will, consequently, be no admissions with conditions under the new plan.

"Students applying for entrance to the University of Chicago present by certificates from approved schools or by examination 15 units of entrance credits. Among these must be 3 units of English and in addition 1 principal group of 3 or more units, and at least 1 secondary group of 2 or more units. These additional groups may be selected from among the following subjects:

1. Ancient languages (Greek and Latin) it being understood that to make a group of 2 or of 3 units the work must be offered in a single language.
2. Modern languages other than English; to make a group of 2 or of 3 units the work must be offered in a single language as under group 1.
3. Ancient history, mediæval and modern history, English history, United States history, civics, economics.
4. Mathematics.
5. Physics, chemistry, botany, zoology, general biology, physiology, physiography, general astronomy.

"In group 5 not less than 1 unit may be offered in either physics or chemistry. Any combination of the subjects within each group is permitted.

"Of the 15 units offered for entrance at least 7 must be selected from the subjects in groups 1 to 5.

"The remaining 5 units may be selected from any subjects for which credit toward graduation is given by the approved school from which the student receives his diploma; but Greek, Latin, French, German (or any language other than English), mathematics, physics, and chemistry, if offered, but not as above under 1 and 5 must each consist of at least 1 unit. Latin may not be continued in college unless at least 2 units be offered."

The foregoing requirements have been quoted at length because they show not only certain changes which have taken place during the past five years but they indicate the present trend in entrance requirements and they also presage the reason for these changes.

It is true that the University of Chicago has no engineering departments but when a university will admit a man into her arts department on four units of manual training there is a reason. As pointed out in the preliminary report of the Committee on Coöperation with Secondary Schools* it has become necessary to take cognizance of the fact that the large majority of students in high school do not go to college at all, nor have they any intention of so doing. The high school is rapidly coming to relate itself directly to the future life-work of its students, without the intervention of a more advanced institution of learning. In consequence, profound changes in curriculum and method are under way which point directly away from the generally accepted notion of college requirements.

It is no longer possible to recognize high schools as "preparatory schools" for colleges and universities. Regardless of college opinion, the tendency in American high schools today is toward a multiplicity of subjects and the development of affairs of life. If it is argued, as it is in some quarters, that a high-school education is inadequate for such preparation, the answer is that the problem is placed upon the high school to deal with to the best of its ability. Not over ten per cent. should control the ninety per cent. of the high-school type.

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* PROCEEDINGS, Vol. XXII, p. 392.

In commenting upon this Mr. Harrison Webb, of the Central Commercial and Manual Training High School of Newark, N. J., a member of this Committee, states: "The point at issue, generally, between high schools and engineering colleges is the number of absolutely required credits. If a student knows from the day of his entrance into high school that he is going to an engineering college, the problem is a very easy one. But in a technical high and in schools of the older type as well, the difficulty lies in the fact that a student does not find himself until he has been in the school from one to three years. Now the formulations are entirely dependent on the year in which the subjects are taken. The simple fact is that the usual college entrance requirement involves a sufficient number of formulations to occupy the time of a student for four years. If, then, a student has spent two years in commercial or classical work he is at a disadvantage as compared with a student whose first two years have been devoted to engineering preparation. That is, such would be the case were it not for the fact that the prejudices of an older generation are still so powerful in determining educational values that nearly every engineering school so arranged its required and elective units in entrance requirement that a student graduating from a classical high school can enter without conditions, providing he has a sufficient mathematical course.

"But no such opportunity is open to the student who has entered a commercial course in a high school. At the present time, however, nearly every high school has a course called a general course, in which a student is allowed with proper guidance to choose from a rather wide range of selection. It not infrequently happens that a student in a general course after three years finds that it will take two years more to enter the engineering college without conditions. Of course, the individual cases of this sort can usually be taken up with the college authorities, particularly here in the East, where demand for entering students has in some quarters reached the competitive state. But the problem as it stands is an increasingly difficult one for teachers and school authorities.

"Friendly coöperation between teachers in the technical college and those in the secondary school is needed and will do more to bring about better conditions and even better preparation than any set of regulations that could be devised.

"There are hundreds of able students who ought to go through an academic or engineering college. The time of their leaving high school is the turning point in their lives. The payment of tuition, the lack of parental interest, the temptations of an immediately remunerative position often seem to the students to stand directly in the way of their receiving further education. When to this is added the serious difficulty which comes in so arranging credits as to permit the entrance into college without conditions, the student is more than likely to give up the idea."

Here then is the reason Chicago and many other universities accept commercial and manual training subjects for entrance to college. They recognize the obligations which the high schools are under to serve their own communities in the most efficient possible way without primary regard to college entrance requirements. Having in mind the desirability to render as flexible as possible the conditions under which students may enter college, they demand only such requirements as seem indispensable to the continuation of the educational work begun in the schools.

This tendency has been developing rapidly and, as might be expected, is especially marked in state institutions. This does not mean that there has been a let-up in the requirements during the past five years; on the contrary the number of Carnegie units has very generally been increased.

Many of the colleges which previously required 14 units now require 15; and those which required less than 14 have increased to 14—in one case the requirements have been increased from 8 to 15 units. In many cases, especially in state institutions, the requirement demands graduation from a four years' course in an accredited high school or in lieu of this an examination in 15 units of work.

At the same time it must be recognized that subjects offered for entrance may seem to be high without their being thorough. This is true of the sciences as taught in many high schools poorly equipped for laboratory work, in which the whole field is attempted to be covered instead of confining the work to such courses as outlined, for instance, in the 1910 report.

The situation of the modern languages at the present time is uncertain. Many colleges do not require any foreign language for entrance although it is accepted as an elective. Others have removed foreign language from the curriculum nor do they require it for entrance. Several institutions which formerly required two foreign languages for entrance now demand only one. On the other hand, there is a desire on the part of some engineering colleges to eliminate modern language from their courses but require it for entrance.

It is to be hoped that the high schools in working out their curricula for the good of the individual in their respective communities will retain the modern languages for aside from their practical value as pointed out by Mr. Abraham Flexner, they have an educational value in training the memory not possessed by any other study. It is, moreover, logical to have the languages studied in the earlier years for in these years language is mastered with the least effort.

The Yale-Harvard plan has great merit and doubtless this method will be extended to include many other colleges, for it is recognized that the certificate plan without some qualifying system may become a drug on any institution. Lacking any criterion of quality in the preparation as determined by a few comprehensive examinations of the candidate for admission, the college must make provision for determining and maintaining the quality of the work of its constituent schools. This, at the present time, leaves much to be desired but a closer articulation between college and school is quite possible and should be maintained in order to secure the best results. Accredited schools should mean something more than the possession of a certain amount of physical equipment.

Recognizing the desirability of the high schools to confine the education of their pupils to the needs of their particular communities, it is inevitable that if the engineering colleges insist upon a requirement of practically four years of high-school work, some of this may have to be commercial or industrial if the engineering school is also to fill its sphere of usefulness in the community. Having this in view it seems reasonable that the engineering colleges should demand such preparation as will enable the students to satisfactorily continue their work in the college, and in addition such electives from an approved list of subjects which will tend toward a breadth of intellectual development; outside of these required and elective subjects the engineering college must be content to accept such subjects as may form a constituent part of any approved course in an accredited high school.

The requirements for admission then would be as follows: Eight units or seven from a list of prescribed subjects as given on page seven of this report; four or five units from a list of elective subjects as given on page seven of this report; and three or four units acceptable for graduation from the particular high school from which the candidate enters.

QUOTATIONS FROM REPLIES TO QUESTIONNAIRE.

Our entrance requirements are the same for engineers as for students in arts and sciences. Swarthmore College.

Technical schools must require certain units for admission on account of the character of their work. This being done, I do not see why any other work should not be accepted without regard to the subjects. This statement is made on the assumption that high-school graduates are being considered. Case School of Applied Science.

Nine units required, 6 units elective. Of these two must be chosen from the following: Foreign language; English; History-civics-economics group; Mathematics; Natural Science;

and four may be chosen from any work certified as accepted by the accredited school for graduation. University of Iowa.

Ultimately I hope to bring about the requirement of an actual examination in English and elementary mathematics and in one language other than English; but our own situation is such that at present I do not think the change would be advisable. University of Virginia.

For admission to the college of liberal arts, we have this year dropped the requirement of solid geometry. I am somewhat fearful of the result that this may have on the school of applied science, but it seemed necessary for us to drop this requirement, inasmuch as the great majority of schools in the state found it absolutely impossible to teach the solid geometry. University of North Carolina.

During previous years we required college algebra for entrance and did not teach same in college. We found, however, that college algebra taught in high schools is unsatisfactory and we decided to teach it in our freshman year and require for entrance intermediate algebra. This change has led to better preparation in the field covered in the high schools and much better knowledge of mathematics at the end of the freshman year than under the old arrangement. Clarkson College of Technology.

Additional units up to a maximum of four, accepted in drawing and manual training, provided that any school offering such work for credit must be especially inspected with reference thereto. Unsigned.

(1) A candidate for admission must be a graduate of an accredited high school or other accredited school, and must offer units in prescribed subjects (English 3, mathematics 3, physics 1) and eight elective units not more than three of which may be from vocational or commercial subjects. An applicant who has not been graduated must pass entrance examinations in 5 units (English composition 1 unit; algebra 1 unit; additional subjects to be designated by the university authorities, 3 units). (2) A candidate must present 15 units in acceptable subjects at the time of admission. It is pro-

vided, however, that a student who offers 15 acceptable units, including algebra 1 unit, English 3 units, plane geometry 1 unit, and science 1 unit, but is deficient in advanced algebra ½ unit, or solid geometry ½ unit, or both, may be admitted to courses for which he is fully prepared, subject to the requirement that the deficiencies in question shall be removed before he may register for a second year's work. University of Illinois.

The University has become more liberal in accepting occupational and other credits. Since the report of Dr. Mann of the Carnegie Foundation, Secretary of the Committee on Engineering Education from the engineering societies of the United States, in his report says: "That the graduate of the non-technical high school shows just as much proficiency as the graduate of the technical high school in engineering education" we have no recommendation to make. University of Oklahoma.

The only suggestion I could make regarding entrance requirements in general is that it seems to me there are a great many good points in the Harvard scheme of accepting credentials, supplemented by a few test examinations. Personally, I believe this is the line of progress. Sibley College, Cornell University.

(2) The only suggestion I have to make is the advisability of considering whether the entrance requirements to an engineering course should not take into account two kinds of mental ability, each good in itself: (1) that which makes mathematics easy to the student, and (2) the ability to do things which depend upon sound judgment, high development of common sense and an intuitive perception of the relations of ordinary things—the whole ability not associated with ease in acquiring mathematics. I make this suggestion because I have seen so many students who dub in mathematics turn out first-rate engineers when it came to the test of practical life. Queens University, Kingston, Ont.

Foreign language is no longer required (for entrance or for graduation, although accepted for both as electives). Neither are advanced algebra, solid geometry or physics definite requirements, although it is expected that these will be offered in a very large majority of cases. The requirements have been made with the thought of well-rounded rather than special training without losing sight of the fact that many of the students in secondary schools will not know in advance that they will take engineering in college or in fact that they will go to college at all. You will doubtless recognize that we are considerably indebted to the last revisions at the University of Chicago. University of Washington.

Recommend increased requirements in English and arithmetic and modern languages. If we could delegate the latter subject to the preparatory schools, we would be glad to exchange the time required for an equal amount of work in the sciences. We prefer to do the sceintific work, as we are far better equipped for this than the preparatory schools. We would be glad if they could do all of the necessary modern language work and do more work in English and far better work in arithmetic. University of Vermont.

It has been in the mind of the Council of our Engineering Faculty that we should be relieved of the burden of teaching modern languages in our engineering courses. It is thought that by raising the standard in the modern languages required, which are chiefly German and French, to about the equivalent of the first-year course in arts in these subjects, the men would have sufficient acquaintance with these languages to enable them to read technical literature and we would be able to devote more time to technical subjects. University of Toronto.

The elastic requirements to the college of liberal arts forced the engineering colleges to modify their entrance requirements. Foreign language has been removed from the list of constants and placed in the electives for entrance. Instead of requiring physics at entrance we require one year of science but state that physics is preferred. At least six hours of foreign language must be taken in the college unless student offers two units of French, German or Spanish at entrance. University of North Dakota.

Total required units 9; list of optional subjects omitted and 6 credits accepted from "other subjects taught in an approved manner in an accredited secondary school." University of Nebraska.

It is desirable to require mathematics including what is usually the first year college course for entrance to an engineering college for those colleges which can do it. We can not. Washington and Lee University.

DISCUSSION.

Professor D. C. Jackson: I want to suggest that this Society can of itself do nothing with entrance requirements. Of course, it must coöperate with other associations and organizations. If this Society uses any influence at all, it ought to use its influence toward strengthening preparation in the old-time subjects, such as philosophy, Latin and Greek because these are the things which men who enter our engineering schools will see little more of, so far as the elementary work in the profession is concerned, and for our own needs we should emphasize the importance as preparatory subjects of properly taught English, mathematics, physics and chemistry or biology.

Our students in the engineering schools will get all the shop-work and things of that kind which are necessary. Therefore, it is really important that we use our strongest efforts to obtain entrance requirements for the engineering schools which allow only the minimum of artisanship work, like shop-work and similar characteristic work, although these subjects are very appropriate as a part of the entrance requirements for the college of arts, where the student proposes to go on with study, particularly in the classics and philosophy and literature.

Professor Wm. Kent: I think it is practically useless for the Society at this time to try to discuss this important subject. Any report by a committee ought to be put into print and distributed to members of the Society one month before the meeting. It is useless to present a report in this way. reading it from manuscript to people who do not understand.

Professor H. S. Philbrick: I understand that the report of this committee contains the statement, or at least leads one to think, that the schools should be met by the engineering schools in the matter of requirements; that is, that the requirements for engineering schools should in general meet the graduating requirements of our high schools.

Now, I believe that is a very important statement, and I think the conclusion is quite right. In the great technical high schools in our cities, certain studies are taken and certain requirements are set for graduation. If we change our ideas in the engineering schools, it should be with a view to meeting these requirements; and I believe that it can be done in most cases with very slight changes in our own entrance requirements. We must have the idea that these boys are entitled to go to college if they want to. If we do that, we shall open the door to a great many boys who are technically trained; we shall admit them to our colleges, and give them greater technical training, and also that general education which most of our engineering schools can give.

I am glad to see this statement. I hope I have not misinterpreted it. If I have, I have then stated the attitude which I think engineering schools should take.

Professor Wm. A. Hedrick: The requirement of giving three credits in English, and the second requirement of allowing either physics or chemistry, and not both, are things I should like to speak about. I know a number of English courses in which Chaucer is a large part of the course. It is a question with me, could not the English work required of the student who is to study engineering be obtained with fewer credits out of the total, and have more credits given for subjects of scientific importance?

Then the question of drawing is another one. Freehand drawing—could not that be defined in some way closer than it is? If freehand drawing is drawing vases, flowers, etc., couldn't the Committee and the Society suggest to the schools that they take up the drawing of such things as one might encounter in engineering—something outside the conventionalized decorative art subjects?

Professor C. M. Wirick: The report is given almost entirely to a statement of the conditions found in these schools, and of the advice received from members of the Society or from institutions.

However the colleges may feel about it, it seems to me, from what I know about the secondary institutions in the west, that you will either accept the graduates of these schools as they come out, or you won't get them at all. The high schools have grown entirely away from the idea that they are fitting boys for you to take. They do not have that attitude at all, if they ever did have it. They are there for the benefit of their clientele, in the neighborhood, in the city, in the state, and you may take it or leave it, just as you choose.

I suspect that the actual fact is that very few changes need to be made in bringing about coördination. Unless the engineering schools are prepared to take the students as they come from the high schools, they won't be prepared to take very many from large regions in the country. The high-school people look on the attitude of college men as being dictatorial, telling them what they shall do and how they shall do it. I can't help thinking that the course in many of these schools is admirably fitted as it stands for entrance to engineering schools. It seems to me a certificate and an examination together would be an admirable method of sifting the students who enter.

Professor F. C. Caldwell: I fully agree with Professor Jackson that it is desirable for the man coming into the engineering school to have as broad a preparation as possible, and not have to sacrifice cultural studies in favor of subjects like shopwork. But it does seem that it is a very grave question at the present time whether the study of the ancient languages is the best way to obtain the desired breadth. Such studies carried through high school and college give a man a broad and valuable training; but as taught to high school students, who have little or no interest in them, they are of questionable value as cultural subjects. In this I am speaking as one who was brought up on Latin and Greek and who in a way enjoyed them. If we could get the right kind of work along the lines of history, economics, sociology, and literature it would, I believe, be of greater value as cultural education. It also seems to me most desirable to develop a greater interest in reading modern literature, which very few engineering students possess.

Dr. C. R. Mann: May I inject a few facts? It may be of interest to the Society to know that the Massachusetts Institute of Technology made a very careful study of the standing of the students who have come from the various types of schools; and the students who made the highest average record at that school are those who came from the public high schools. The technical high school men have a lower record by several points.

Item number two: The colleges for the last twenty-five years have been carefully specifying what the high schools shall do; and the result is shown in the records of the College Entrance Examination Board,—the percentage of students who fail is not growing less. There is an opportunity for the engineering school to bring about an improvement in the matter of entrance requirements by not demanding a unit of this or a unit of that, but by demanding certain abilities and by defining those abilities. By the right kind of tests, you will be able to find out whether boys have the proper kinds of ability. If you attack the problem from that point of view, you have a real contribution to make.

REPORT OF COMMITTEE ON ADMINISTRATION.

Committee No. 9.

BY F. H. CONSTANT.

This Committee owes an apology to the Society for the length of its questionnaire. In exchanging views by correspondence, it soon developed that all-year-round work was inseparably connected with summer work; and it seemed wise to develop the questionnaire to include both. This naturally led to a much longer questionnaire than we hoped for. Experience has shown, however, that some of the questions could very well have been left out.

Employment of Engineering Teachers.

The questionnaire published in the June, 1916, *Bulletin* relating to the employment of engineering teachers is the joint work of this Committee, but owing to delays in sending it forth and the slowness with which the replies have come back (they are still coming) the other members of the Committee have had no opportunity to see them, much less to formulate a joint report. The chairman, therefore, will have to report progress and be content at this time to give only a brief resumé touching the general nature of the replies. It is based upon about 195 answers, classified as follows:

Group I, from teachers of professional subjects (145 replies).
Group II, from teachers of applied science (11 replies).
Group III, from teachers of pure sciences (39 replies).

The lines drawn are not sharp but it is proper to take into account some difference in point of view. It must also be understood that from the very nature of the questionnaire no accurate tabulation of the replies on a percentage basis is possible. Such a tabulation can only be broadly approximate.

The purpose of questions 1 to 5 was to get some statistical information of the outside work actually being done by engineering teachers. The number of replies is insufficient to give more than a general idea of conditions and the opinion of engineering teachers regarding this vital matter. A much larger return is earnestly solicited, the results to be published at a later date.

The replies to *question No. 1* are tabulated below. The groups (I, II, and III) refer to those listed above, while the headings of the column refer to the different kinds of work as classified under question 1.

All replies not representative of the conditions of the average teacher with the normal length of vocation (from 12 to 15 weeks) were excluded.

Group.	*A.*	*B.*	*C.*	*D.*	*E.*	*F.*	*G.*	*H.*	*I.*	Replies Used.
	Percent.									
I	5½	6	11	6	6½	27.2	8.8	22	4	116
II	11	8	5	2½	11.7	29	15.2	14.5	1.1	11
III	12	10.4	10	7.3	7.2	12	8.6	25	7.8	39

Answers to *question No. 2* are tabulated below. In this group all teachers were included, whatever the length of vacation.

Group.	*D.*	*E.*	*F.*	*G.*	Replies.
A	4	3.5	4.4	2.2	126
B	6	2	13	1.5	11
C	4.3	2.1	5.8	1.6	38

The uncertainty of securing even approximately accurate results will be appreciated. They indicate merely the relatively small amount of time given to outside employment during the college year. It was naturally *D, E* and in some cases *F* which were continuous.

Question 2 I (b).—With few exceptions practically all answered *no.*

Question No. 3.—This was not a valuable question and was answered more specifically under No. 4 and No. 7. Generally all work undertaken increased both income and experience.

Question No. 4.—Again a detailed answer is not possible. In Group I generally all report a favorable reaction upon the teaching work for the following reasons:

Exchange of ideas with practical men.
The broader and especially the economic viewpoint.
Greater interest and enthusiasm in all work.
Vitalized teaching.
Keeping up-to-date.
Outside practice furnishing valuable illustrative material for class-room.
Greater confidence of the students in the teacher who is himself practicing what he teaches and has standing among business men.

A few noticed no effect one way or the other.

There were practically no answers to this question from Groups II and III.

Question No. 4 (a).—That work which relates to the investigation of specific problems or illustrates new applications of fundamental principles was considered of the greatest value.

Question No. 4 (b).—The work of least value is routine, field, statistical or clerical work, the small job, summer teaching, administrative detail, repetition of past experience, or anything undertaken for money alone. Many were unable to discriminate between (*a*) and (*b*), finding all of their work of value. Generally *D* and *F* are most satisfactory, and *G* and *I*, least.

Question No. 5 (a).—In Group I two thirds report ability to get summer work. It covers a wide range such as drafting, design, field work, mine examinations, laboratory and plant testing, expert testimony, railway work, research, highways and drainage, shop, parks, U. S. Geodetic Survey, inspection, consulting, etc. The remaining third either do not answer or report that they have not tried for summer work or have no opportunity to get any. In Group II, 9 out of 11 get summer work, covering a similar range. In Group III, 9 out of 39 are successful, covering design, drafting, shop, testing and consulting work.

Question No. 5 (*b*).—Forty-five per cent. do more or less work throughout the year. Most of the remainder (thirty-five per cent.) report little or no opportunity for such work.

Question No. 5 (*c*).—By far the greatest difficulty in securing summer employment is the shortness of the vacation and the difficulty of getting a creditable piece of work (of good professional standing), for a 10- to 14-week vacation. Seventy per cent. report such difficulty. An insignificant per cent. state that they have no difficulty. A few have found that their sequestered life as teachers does not give them the public acquaintanceship and standing necessary to command confidence and consequent employment. Twenty-five per cent. do not answer.

Question No. 5 (*d*).—It is impossible to draw any conclusions from the answers since few state whether the percentages given are based on total income or on the monthly, daily or hourly schedule. Thirty per cent. report outside income negligible; twenty per cent. do not answer and the remainder are able to make from 5 to 400 per cent., the latter being on the hourly basis. Probably most of the replies are on this basis, in which case, for the majority the outside pay is somewhat better than that of the college.

Question No. 5 (*e*).—About forty per cent. answer with a modified affirmative; a few have a limited amount of time; seven and one half per cent. do not answer; about sixty per cent. answer no.

Question No. 6.—There is a unanimous and very decided affirmative answer to this. Many state that outside experience is absolutely essential; and in some colleges only men who are in such contact with outside practice are retained on the teaching staff. The following reasons are given:

Keeps the teacher up with the times.
Keeps him in touch with the industry he serves.
Gives him a higher standing with his students who look up to a man whose abilities are sought outside.
Makes him more practical.
Brings him in contact with actual conditions and working men.
Gives him a change from teaching and is, therefore, a rest.

Many, however, modify this decree. Such outside work should be done with moderation consistent with the man's strength. It should be in line with the subjects taught and should be stimulating and productive of new and valuable experience rather than of a routine or pot-boiling nature. Nearly all acknowledge the need of some genuine vacation of two or three weeks' duration for rest and play.

Question No. 7.—The replies show a difference of opinion and when affirmative are generally modified. Fourteen per cent. are flatly opposed to work during the college year on the ground that it will interfere with the teaching. The outside work is exacting and can not wait. It is easier to neglect the class room work. When the teacher absents himself from the class-room it reacts psychologically upon the students, who feel themselves neglected. Even if he is not actually absent from the scheduled class periods, he cannot oversee nor correct their work as thoroughly as he should, nor prepare himself properly for the class-room. The outside work is generally more fascinating than teaching and is apt to enlist his major interest. If he becomes too absorbed in practice, he may emphasize practical methods rather than fundamental principles. A few raise the delicate and much debated question of the propriety of the teacher competing with practicing engineers, especially with his own graduates.

While these dangers are recognized by nearly all, a majority, eighty-four per cent., favor a limited amount of all-year work properly safeguarded. The difficulty of getting good short summer jobs is recognized and all-year work seems the natural solution. All agree that it must not be allowed to interfere with the quality of the teaching. It is justified only when it makes him a better teacher. It should be of a dignified nature and reflect credit upon the man and the college.

In regard to the amount of such work, a few place numerical limits ranging from four per cent. to one third of his working time, but in general it is made to depend solely upon non-interference with college duties, a matter to be worked out between the college authorities and the man's own conscience. His standing both in the college and in his profession is the controlling factor. The older man may safely take on more outside duties than the younger man who necessarily must bear the burden of a heavier class-room schedule, and who is still passing through his apprenticeship in the art of teaching. On the other hand the younger man needs a shorter rest in the summer and can accordingly take on a larger amount of summer work.

Question No. 8.—While many replies name study and research as the best mode of summer employment for teachers of pure science, a number suggest practical experience in engineering. There is, however, a meagerness of detail as to how they are to get it. The object is clear enough, to acquire at first hand a knowledge of the application of the principles which they are teaching to the real problems of life. There is a tendency to group I and II together, advocating practical engineering experience along the line of the subjects taught for both groups. In Group II a little more emphasis is placed upon shop and laboratory research.

Question No. 9.—The answers are meager. Some reply tersely by saying "none," or "take the best that offers," or "any employment rather than idleness." Another puts it differently, saying, "take the best and refuse others." However, quite a list of "don'ts" is given, many of which have already been mentioned. Some of these are:

Everything not engineering.
Whatever does not enlarge the viewpoint.
Whatever is injurious to health.
What is merely routine.
The purely commercial.
Summer teaching, etc.

Question No. 10.—There is a divided opinion. Nearly all the affirmative replies (forty-two per cent.) are modified, stating that the plan may work in special cases, and that it is more applicable for the older than for the younger men. Fourteen per cent. are still more doubtful of its wisdom, while forty per cent. are emphatically opposed. In no case should more than a small per cent. of the faculty be so employed. The benefits to college and student are the same as those from all outside employment.

Question No. 11.—There is a rather emphatic opinion that the plan of No. 11 is preferable to that of No. 10. Fifty per cent. favor this plan, eleven per cent. are in doubt and thirty-two per cent. consider it impracticable except in special cases.

Question No. 12.—This question has already been answered.

Question No. 13.—While a few favor a complete rest throughout the entire vacation, reserving part of the time for study and preparation, the opinion is pretty emphatic and nearly unanimous that change of occupation with a little recreating rest of from two to four weeks answers the purpose sufficiently.

DISCUSSION.

Dean A. H. Fuller: While I had nothing to do with the preparation of the report, I had an opportunity to glance over it for a few moments. I will confine my discussion to a few points.

Although the number of replies is altogether too small to draw conclusions from, there are indications that the amount of work done during the year is very small—say five per cent. of the total time of the teachers; and that the summer work perhaps exceeds twenty-five per cent. of the total "vacation" time, involving about forty-five per cent. on the members who reported.

The replies to question 4 and question 6 are very much along the same line. They indicate that outside work is desirable and perhaps necessary for the engineering teacher.

Going on to question 8, the nature of the work, it does not seem to me that the question was worded right or that the replies brought back what was most wanted; that is, the nature of the work as indicated does not seem to me to be that which the engineering teacher should be engaged in. From the highest standpoint, it would be desirable to have the work of the college professor confined to those problems upon which his advice is sought for consultation. We will have to admit that we cannot all reach that point. Some of the engineering teachers are so fortunate as to have extended experience before coming into the teaching field, and they have reached that high degree of eminence. The man who goes into teaching early cannot reach it without doing outside work. The four or five per cent. of work done through the college year, and the twenty-five per cent. or more during the summer, is not enough for this.

Going to question 10, regarding the part-time work, I think the answers indicated rightly that that is not the way to get outside experience.

Question 11, in regard to breaking off from teaching for one or more years at a time, seems to me to suggest a most desirable method of keeping in touch with engineering work. This can be handled through an occasional leave of absence or perhaps, by breaking away for a series of years and then taking chances on getting back into teaching again.

Referring to Question 9, as to the nature of work to be refused, I do not agree with the gist of the answers. I certainly do not agree with the type of answer which says, "Take everything you can get." The relation between the engineering teacher and the practicing engineer has been discussed considerably; but it is one question upon which there is no satisfactory agreement. Practicing engineers of course, recognize the right of engineering teachers to practice—under conditions that are fair. Many engineering teachers have antagonized outside men and brought discredit upon the professor by taking up lines of work for which they are not prepared. A teacher should refuse work which he can not handle in a creditable manner. If the instructor is particularly fitted for structural work, let him pass the sewer job which is offered him over to a colleague or to some engineer who is practicing along that line. By following this policy and taking care that compensation is kept upon a strictly professional basis, friction between engineers and educators would be replaced by hearty coöperation.

Professor D. C. Jackson: I suppose that Professor Constant asked me to come into this discussion because I wrote a letter taking some rather sharp issues with his questionnaire.

The first question of the questionnaire says: ''Give the number of weeks covered by your summer vacations and the percentage of time which you have devoted during the past five summers to employment, classified generally as follows: Teaching, Study, Preparation for work of following sessions,'' and so on. Give this for five years. I answered that in my opinion, most active men who are properly fitted to be professors of engineering of the finest type do not keep records of their ways; and that these various employments react upon each other in such fashion that they can not be separated. For instance, during the summer a man may not do any teaching; but if he is doing professional work along the line of next year's teaching, he is preparing for the latter also. Again, he may spend the summer in study and the subject may be outside his teaching line; yet, it may well be that it adds fruitfully to his teaching in the following session. If a man is doing research, he will be studying; if he is writing books, the same thing is true; and each of these will usually add to his fruitfulness as a teacher.

In respect to the summer vacation, I happened to think of an active-minded colleague of mine at Boston, with whom I was not long ago discussing its proper use. He said: "The other day I was in the office of a banker in the city, and the banker said to me 'Well, I suppose you will soon be going off on your vacation'; and I said, 'No, I don't have time for that; I have to study and work.' The banker said: 'We men of business can not afford to spend three or four months each year in holidays. If we did, we would not be able to do the work the nation demands.'" I believe the banker is right, and I believe his view is applicable to school teachers as well. Amongst many of our faculty colleagues outside of engineering I think the opposite opinion is held. Some of them seem to hold the proposition that their minds should have three or four months each year in which to lie perfectly fallow, but I do not believe we engineering teachers can follow the latter proposition and fulfill our duty to our profession.

Apparently some answers which Professor Constant has received suggest that it is not desirable to encourage our younger engineering teachers to do professional engineering work, because it may prove too fascinating and they will be lost to teaching. I will say to you that any one who finds such work more fascinating than teaching ought not to be a teacher. I will propose a counter-proposition: It is good for every engineering teacher to get into professional engineering work and if it proves more fascinating to him than teaching, then he should get into the thing he likes most. It is desirable, too, that men should be brought from active practice to teaching, as some of these may find teaching more fascinating and they may wish to remain in it.

Dean W. M. Thornton: What I have to say will relate particularly to our own practice; and that practice represents my views and represents the views of our university. Our governing board—what we call the board of visitors—in times past was a little jealous of a professor giving any of his time to anything but teaching; and so they have had a rule for a great many years—it is a rule even now—that any man who wants to go into outside work shall get specific permission from the board of visitors to do so. That is for the regular session, of course; the vacation time is free. I have never known the board of visitors to refuse permission whenever it has been asked; so we have had men working on outside jobs ever since I knew anything about this university. I have never known a case where on the whole it was not beneficial to both parties concerned.

When our little engineering faculty was organized, we were so impressed with the desirability of such outside engagements that we went to the board of visitors and told them that we wanted the permission of the board for the men to go into outside work, any work that seemed to them appropriate and desirable and compatible with the performance of their college duties. We arranged a schedule of lectures by which the men in the technical branches had their lectures at one end of the week, so they could get away at the other end without interfering with the class-room duties. A man would have class-room work concentrated on Thursday, Friday and Saturday; then he could have Monday, Tuesday and Wednesday for jobs which called him away from the university. We still operate on that plan, in a measure, and I believe the experience of our teachers of engineering has been that the outside work has helped them greatly with their college work. They have done better college work, and the classes have felt the influence of it. So I have never been led to question the wisdom of our decision.

On the other hand, I must say that in a school placed as this one is, in agricultural surroundings, the calls for outside work are not so abundant as they would be in a more highly organized industrial location; and therefore the men are not tempted to do too much. more than men in a normal state of health can do. One of our professors had to give up his outside work because he found it too much of a burden. That is the only case we have had where any trouble occurred. The effect on his teaching was altogether satisfactory; the trouble was with his own strength.

I must confess, as I grow older, that I become more and more reluctant to give up my vacations to routine work. I still keep pretty busy all the time; but I find that routine work becomes more and more distasteful, and I have cut it out to a considerable extent. New work, work that is interesting, work that is stimulating, I think a man may undertake at any period of his life.

It seemed to me, when I read the questionnaire, that there were a lot of unanswerable questions in it. So much depends upon local conditions, so much upon the age of the person who answers the questions. A man would do certain things at one time in his life which he would be unwilling to do at another time. So many things of that sort are involved that I could hardly see that much was to be gained by trying to answer all those questions, without making special reference to the particular circumstances that surrounded the person who answered them.

In conclusion, I should simply repeat that we believe in giving the teachers of engineering subjects opportunity to do professional work, and that our experience has been, almost without exception, that it is in every way desirable.

President K. G. Matheson: I should like to ask Professor Jackson a practical question; that is, if he finds any objection on the part of his graduates to his teachers indulging in engineering work. We are just beginning in Georgia Tech. to do some extension work, and we find indications of serious objections on the part of our graduates. I would like to get the benefit of Professor Jackson's experience.

Professor Jackson: Before I answer that question, may I say to the chairman of this Committee that while I rather vigorously presented my views which differ in their standpoint from the standpoint of the answers which Professor Constant has reported, I want to offer my meed of recognition to the hard work and excellent work which has been put into this inquiry. The answers received are no fault of the chairman, but of those who did the answering. My objection is largely in regard to the questionnaire subject assigned to the Committee.

As I understood President Matheson's question: "Do the alumni of Massachusetts Institute of Technology object to our teachers doing work in engineering practice?'' I do not think there is any objection—there is no serious objection—from the alumni. Indeed the Alumni have criticized some departments in the Institute on the ground that the professors in those departments have not taken a reasonable interest in engineering practice nor an adequate interest in the professional engineering societies. The alumni of the Institute have been rather anxious for such participation by our faculty members; and I think a large part of the eastern engineers would support this attitude, feeling that it is to the advantage of the profession to have a considerable body of engineering teachers engaging in practical work.

Also this question has heretofore been discussed in the engineering societies, and sometimes sharp criticism has been made. But by and large, I think, in the eastern part of the country, and even in the central-northern part of the country, any such criticism has long since passed away; because it is recognized that no engineering teacher is likely to be in objectionable competition with general practitioners when there is such a large amount of engineering work to be done. He is likely to be a desirable factor, rather than otherwise, because he may add a certain amount of additional dignity, perhaps, to the general reputation of the consulting body.

Professor Wm. Kent: I was asked to write a paper for this Society on that very subject several years ago; and Professor Allen of Worcester wrote one at the same time. Both papers are in the *Transactions,* Vol. IX. At that time I asked one professor, ''What do you think about the question of engineering professors doing outside work?'' He said: ''If I did not, I would starve to death.'' The same conditions probably exist today.

Dean C. L. Cory: I first desire to say that the Society is under great obligations to this committee for the information which it has collected, and the discussion of the report of the committee should be of great assistance in properly guiding all of us, including the administrative officers of institutions, in doing what is for the best interest of engineering education.

For a number of years this matter has been given the most careful consideration on the Pacific coast, with the result that one fundamental principle has definitely been established.

I think you will all agree to this principle, which is: *The University comes first.*

By saying that the university comes first I not only mean that any member in any department, whether he be its head or an assistant, shall at all times see to it that his work is so done that the work will be as good as it can be; but also that his relation to the university will be such that everyone, from the president down to the undergraduate, will be glad to have him continue as a member of the academic staff. I am interested in the idea which has been suggested in the discussion that the university graduates may criticize members of the teaching staff for doing practical work because by so doing the university graduates are prevented from doing such work themselves.

If, as far as the member of the teaching staff is concerned, the university comes first, the graduates of the university will also come first, and, no matter how much outside work may be done by the instructor in the university, such instructor will always cherish the opportunity to help the graduates and assist them and not stand in their way.

We can assist our university graduates more in many cases by knowing by experience the character of work they will be required to do after leaving the university, and personal experience with the larger engineering problems not only assists the instructor in becoming acquainted with conditions but it also tends to make such instructor do things more carefully and more thoughtfully than is sometimes his wont in dealing with students in the class room.

I have heard it said that it is not physically possible for one to part his hair and shine his shoes at the same time. Nevertheless these two things must be done in preparing yourself for proper presentation at dinner. My conception of the teacher of engineering is that he must be what is often, in the vernacular, termed "an all round man," and it is just as necessary for him to be able to do real engineering work as it is necessary for him to be a teacher. All of us will agree, I believe, that a teacher of engineering should first be an engineer, second, he should be a good teacher. Perhaps I ought to interchange these and put it this way, that he *must* be a teacher, but he certainly ought to be an engineer.

Mr. Harry Barker: In my work I hear a great deal of criticism of the teacher who is doing outside work. I think the burden of the discussion here has been different from the criticism which comes to me. It is not so much, as I see it, that teachers are competing with engineers, but that the competition, as it is conducted, is unfair. That is, the teachers are using the institution's laboratory facilities and employing the students themselves in commercial work; while the men who get the benefit of all this are not paying what it would cost an independent engineer to furnish the same facilities. Student assistants cost little or nothing. The students like the work because it gives them practice; the teachers like it because it gives the students contact with practical work, and there is opportunity to try the laboratory equipment in practical experimentation. Where the use of college plant and students are not very carefully governed, it gives rise to the kind of criticism which I hear.

Professor G. R. Chatburn: The figures do not surprise me so much in other parts as they do in the columns headed "*E*" and "*I*." Judging from my own experience, I find that the community calls upon me a great deal for outside work; not work that I am paid for at all, but work which is absolutely free. For example. The Commercial Club of my city drafts me for service upon certain street and road and sanitary committees. Other organizations of which I happen to be a member call upon me. Just a few days ago it was decided to erect a new $100,000 Masonic Temple in our city; and notwithstanding the fact that I tried to get out of it, they insisted on selecting me one of the three men to proceed with the building. I, and the other members of our faculty are frequently called upon for lectures and addresses, all of which requires considerable time.

It seems to me that all of this sort of thing counts for an engineering teacher; and, furthermore, I believe that it is but right and just that people who are employed in public and quasi-public institutions of learning should take an interest in community affairs and should devote a large part of their time to those affairs. Some one said to me: "Your vacation is commencing now, isn't it?" I said to him: "If I were as well paid per hour for work done outside the university as I am for work inside, I would not need to be teaching at all now."

Professor W. T. Magruder: Professor Chatburn has made a point which should be emphasized; namely, that when boards of trustees, or chambers of commerce, or other public, or quasi-public organizations ask professional engineers who are teachers to do work for them and to serve on professional committees, it may be their duty to donate their services as consulting engineers to the public welfare; but it is also their duty to tell the organization either to get a competent practicing engineer to do the detail work and so not to cut into the work of the consulting and practicing engineers of their city, or else to employ him regularly as a professional engineer. If we cannot sell our services, but permit others to get them from us for nothing, or below a fair market price, the fault is ours and our competitors have a just right to complain and blame us. We engineers should be professional men and charge for our services as do the doctors and the lawyers.

If President Matheson and the members of his faculty will agree not to cut prices on work as it is offered to Atlanta engineers, there will be no cause for criticism on this score from the graduates of the Georgia School of Technology; and if they will value their services at from ten to twenty-five per cent. above the prices as charged by Atlanta engineers, there will be no competition and cause for just recrimination. At our institution, an extra price is charged for cream and milk furnished by our dairy, and so there is no competition with the regular milk dealers. Purchasers of our dairy products pay an extra price and count on getting an extra article. It is interesting to note that the demand exceeds the supply.

This is the same old moral, ethical, and professional question of cutting the price of the regular practicing engineer. If an engineer in a city, with an office to maintain, will do a piece of work for one hundred dollars, and I offer and do it for fifty, he has good reason to complain. This is particularly true of routine work and where university property is used gratuitously.

On the other hand, my observation is that the practicing engineer will usually take everything that comes his way and send to the teaching engineer only those pieces of work that he cannot handle to advantage, does not understand, or has not facilities for performing.

REPORT OF COMMITTEE ON MATHEMATICS.

Committee No. 10.

BY L. C. PLANT.

The following questions were sent to heads of departments of mathematics, physics, and mechanics:

1. Does your department keep informed on the work given by the other above-mentioned departments
   (*a*) By meeting with these departments for discussion?
   (*b*) By becoming conversant, through acquaintance with texts or lecture notes, with the subject matter offered by these departments?
2. By what means and to what extent do you endeavor
   (*a*) To prepare your students for the particular work to follow?
   (*b*) To base your course on the foundations laid by the courses which precede?
3. When selecting your faculty do you take into consideration their preparation, ability and tastes in the other subjects mentioned as well as in the subject they will teach?
4. Will you state in what ways coördination in these subjects may prove helpful?

The following summary of the replies is stated in percentages. You will appreciate that these percentages are only approximations, however, inasmuch as it is rather difficult sometimes to place a reply in a particular field.

One hundred and twenty-two replies to the above questions were received. In different institutions mathematics and physics, physics and mechanics, or mathematics and mechanics are under one head. These replies, therefore, in many cases include information concerning more than one subject.

Twenty-five per cent. of the replies to question 1(*a*) are in the affirmative, while fifty-five per cent. say the departments keep informed on the work given by the other mentioned departments indirectly by frequent informal discussions with heads and instructors of the other departments.

In this connection, I feel like enlarging a bit on question 1(*a*). I gathered from the replies that in the main this information was gathered informally. I am afraid that in many cases it happened something like this: the mathematician is walking across the campus, and meets one of the instructors in mechanics. They discuss as they walk along the relation of the departments. This counts as keeping informed on what is done in other departments.

Seventy-five per cent. of the replies to question 1(*b*) state that the department keeps informed in a general way on the subject-matter offered by the other departments.

Fifty-eight per cent. of the replies to question 2(*a*) state that some effort is made to prepare students for the particular work to follow.

In this connection, there seemed to be a slight misunderstanding on the part of a few people. You know we say: "prepare students for the particular work to follow." Of course it is understood that we teach mathematics in order to lay the foundation for physics and mechanics in a general way; but we had in mind the particular work in this particular institution.

The following typical replies will give some idea as to the means used:

"We endeavor to prepare our students for the particular work to follow by means of special lectures as well as informal discussions."

"We endeavor to prepare our students for the particular work to follow, first, by borrowing illustrations for lectures and laboratory work from subjects ahead; secondly, by emphasizing whenever possible the application of present processes to future work; thirdly, by encouraging proper collateral reading."

"We devote a good deal of time to fundamentals, and then give a great many problems taken from mechanics and from engineering texts. This requires a small amount of extra explanation.''

''The heads of the various departments submit outlines of work required to meet their needs, and the course in physics is adapted to these in so far as possible.''

''One recitation each week is devoted to problems, which have particular bearing upon engineering topics. For example, we devote especial attention to the relation of practical units to absolute units, measurements of mechanics, heat, and electricity. We have an understanding with the members of the engineering faculty that certain subjects in physics will be emphasized, and other subjects touched upon lightly, depending upon the nature of the course which is to follow.''

''The teaching staff (in mechanics) includes graduates in civil engineering, mechanical engineering, and electrical engineering. Thus the staff is fairly well informed on the nature of the work to follow. By inquiring we get still other information about subsequent work and we aim to make our courses cover subsequent needs. I estimate that fifty per cent. of our instruction is based on subsequent needs (in college).''

Forty per cent. of the replies to question 2(*b*) state that either through acquaintance with texts used in preceding courses or by interchange of instructors they are fairly well acquainted with the particular preparation of their students.

Sixty per cent. of the replies to question 3 say ideally, yes, but in practice, it is difficult to find the man who can qualify or to find the money with which to get the man.

Question four, ''Will you state in what ways coördination in these subjects may prove helpful?'' received such a vigorous response that it seems wise to quote at some length from these replies. The following quotations are taken about equally from departments of mathematics, mechanics, and physics:

''Answering somewhat in the negative we would say that we do not see how instruction can be effective without some coördination.''

"The instructors in each department should know just what the students have had in other departments and not accept 'never heard of it before' as an excuse from students."

"Coördination would be a saving in time and would make for efficiency in teaching."

"One way in which coördination would prove helpful would be for departments to furnish lists of problems and principles which the student will encounter in his later studies."

"I think that coördination may prove helpful in the discussion of such subjects as mass, velocity, and motion in general. Students frequently are confused by the explanations of the physics department differing from those of the mechanics department. After a conference these things could be explained similarly and save a lot of discouragement on the part of the student and energy on the part of the instructor. Coördination between mathematics and mechanics may improve the results in the mathematics department by bringing about a closer relation between pure mathematics and its application and relieving the mechanics department of some teaching of pure mathematics. There is danger that instructors may go to the extreme in either direction and conferences and discussions will be helpful in promoting efficient work, efficient as measured by that which the student acquires in the courses. For all three departments coördination will enable a similar presentation to be made in subjects touched upon by each and the emphasis may be placed to bring out the individual point of view without danger of confusion."

"Coördination would mean a saving of time of the pupil."

"Exact knowledge in each case of what the other is teaching is the only basis of successful coöperation. Our instructors visit (for a whole semester) classes in mechanics, hydraulics, and other subjects demanding a knowledge of mathematics, and it would do some engineers *good* to visit our classes."

"In the crowded state of the present engineering courses, we have found it absolutely necessary to give some time to adjust the differences in notation used in the various departments, especially in the matter of the calculus. We have also found it necessary to coördinate the work of the above-mentioned departments as fully as possible. We have found that a student who is grounded thoroughly in our department in the calculus developed by the method of limits has great trouble when he comes to the engineering courses using text-books in which the relatively old and antiquated methods in the calculus are used. Some effort is being made to get rid of this difficulty, but at present, the best solution does not seem to have occurred to us."

"I believe in the method of all working together."

"Coördination would impress the student with the mutual importance of these allied subjects and help to remove the impression that they are separate and distinct."

"Coördination would mean greater interest on the part of the student. It would mean breadth of view of subject on the part of the instructor, mutual helpfulness and better understanding between departments."

"I find the greatest need for coördination in problem work. Much time can be saved and better results obtained when the problems are so stated and so discussed in the three departments mentioned above, that the students realize the intimate relations between these subjects. The theoretical discussions in these departments will necessarily be from somewhat different points of view."

"Each should be reasonably familiar with the work of the allied departments. This is just as true of the engineering department as of the mathematics department. One trouble is that the 'engineer's math.' is not up to date, and the same is true, perhaps, of the mathematician's applications."

"Coördination would avoid the unsatisfactory results brought on by a disjointed course. It would secure the proper repetition of those facts and principles which are fundamental, and which must be repeated a number of times before a proper understanding is attained. Proper repetition is a keynote in education."

"Each department should make its own work dovetail into the work of the other departments in such a way that the students are led to see that the relation existing between them is very close. The teacher in mathematics should keep constantly in mind the fact that his work is to become a useful tool in the hands of his students for dealing with future difficulties."

"Teachers in earlier subjects would know more clearly what particular points should be drilled on for benefit of following courses. Teachers in later courses would know more clearly what preparation to count on. Some unnecessary duplication would be avoided."

"I believe that formal conferences between the faculties of mathematics, physics, and mechanics would prove very beneficial in coördinating the work of these departments, provided, of course, these conferences were entered into in the right spirit and with a determination to fully coöperate."

In a few institutions an engineering council, composed of the heads of departments, has charge of courses of study and hence the sequence of studies. This council in some cases looks after coördination in a limited way.

Conclusions of the Committee.

The need for more thorough coördination of mathematics, physics, and mechanics seems so imperative that it should receive careful sympathetic attention by the departments concerned.

The Committee believes that is it very desirable that teachers in all of these departments be men of broad interests and broad knowledge and that they should be reasonably informed concerning the work in the other allied departments. It is evidently too much to expect under our present conditions of salary and tenure of appointment that a given man should have been trained as a specialist in more than one line. For this reason we believe that it is unwise to require that a teacher in one department shall have specialized in another. It is not too much to expect, however, that his sympathies be in the direction of scientific and engineering work.

It is the belief of the Committee that on certain mooted questions, such as the questions in mechanics which have been discussed recently, it would be preferable from the standpoint of the student for the whole faculty to adopt some one of the proposed schemes even though it be not the best one rather than that the same student should struggle with all of these points in view. Thus we believe that it is far more important that an agreement be reached in each separate institution than that there be an agreement between all institutions since we may assume that no one point of view is utterly bad.

We therefore recommend that this Society recommend to the various institutions that each institution attempt the formation of a committee to include representatives of all departments affected and that this committee be given as broad powers as local conditions will permit. This same committee might discuss such questions as unification of notation, the use of integral tables and other tables, and so forth.

If successful coördination is accomplished it will be accomplished by the mathematics department giving the student the proper mathematical perspective of physics and mechanics and by the departments of physics and mechanics developing their work in such a way that mathematics, physics and mechanics form a continuous science. This does not mean that physics and mechanics need be overmathematical.

Such a coördination of these branches would require that the mathematician keep informed on physics and mechanics, both theoretical and applied, and that the teachers of physics and mechanics have a good working knowledge of mathematics.

Discussion.

Professor E. R. Maurer: Replying to the invitation of the Secretary to discuss this report, I said I might have something to say on the subject. As it turns out, I have no contribution of any considerable value. But I do want to say that the results of this questionnaire and the report of Dr. Mann have greatly strengthened my belief in the value of coördination.

Dean W. M. Thornton: I do not think it is necessary to consume much time in this meeting with anything I might say. We have a small school here. We all know each other well. Four out of the five professors in our engineering department and all the assistants were educated here. The instructors in physics and mathematics came to me for mechanics. I do not find any lack of coördination. There is a lack of effectiveness sometimes in the teaching, due to the fact that the classes are driven too fast; but I do not think that comes from a lack of coördination. If we had more time to speak on each topic I believe the results would be satisfactory.

There is a little lack which has come up recently, but the topic has not been included in this paper. Physical chemistry is given to our chemical engineers; but they are admitting medical men to the same course who have not had calculus. I think that is a place where coördination might brandish the big stick and do something.

Generally, I think we are pretty well interlocked from the fact that our teachers have studied in the college schools in physics and mathematics, and the mathematics and physics teachers have been taught by us. We have not such a large force, nor have we drawn them from so many different directions that they need to be taught what is being done in the other subjects.

I always get the new text-books which are to be used in the departments allied to engineering and see what the classes are going to do. I think the other professors do the same thing. For reference we use the books which are used as texts in these other departments.

As we have all been living so closely together and walking hand in hand for a long time, I believe each professor knows pretty well what the others are doing. There is no question as to the importance of that knowledge, as the Committee has pointed out. You could not get effective work done in any correlated subjects unless each man knew what the other men were about.

As far as possible, we ought to remove stumbling blocks from the way of our students. We ought to be careful about that in every department, particularly so in closely connected departments. I hope the counsel of the Committee will be heeded everywhere; and I believe that we might benefit by it here to the extent of having formal meetings for the consideration of these things, and making sure that we are not too confident as to our walk. I believe these meetings would be of great benefit to us. We have trusted so far in our relatively small numbers and in fact that the teachers do know each other pretty intimately in a social and friendly way, that they do talk about their work together, and keep acquainted with books and lectures used in the related departments.

Professor G. R. Chatburn: You can get closer coördination if you have a department of engineering mathematics than if you have the department of mathematics in the arts college give the ordinary courses to the engineering students. The same is true of physics. However, in our own institution, while we do not have separate systems, we have had very good coöperation with the mathematical department; extremely close. With the physics people we do not yet have the close coöperation which we desire. I tried three or four years ago to see if something more in the line of coöperation could not be brought about. I wrote letters to the several departments of the engineering college asking them to state to me explicitly what they would like to have me teach in mechanics. Each of the departments acknowledged my letter very courteously, but only one made a single suggestion. The rest of them had no recommendations to make.

Dean P. F. Walker: Since this is a sort of personal experience meeting, I might say that we have at the University of Kansas something which is beginning to approximate the situation at Colorado, with particular reference to mathematics and English. In each of these branches there is a member of the department under the college of liberal arts, who is set aside to supervise the engineering work. The work is carried on in our own building. The man in each case is in direct charge of the work given to the engineering students, and is making a special study of the needs of engineering students.

I might add that when men are selected for these departments I am consulted with reference to desirability and fitness, so that we are somewhere near the situation which Dean Ketchum has presented. We are doing something also to develop certain other lines of work, such as industrial economics, in which we are giving the work in our own branch of the institution by one of our own men. For the fundamental course in economics our men go to the economics department, but we choose to give the applied courses ourselves.

Mr. Willis Whited: I would like to make a few suggestions regarding engineering mathematics. Mathematics is a very extensive subject, no man can hope to cover a very large proportion of the subject in a lifetime. Some branches are extremely useful to the engineers, others are of comparatively little use to him. Still others, so far as can be judged at present, are of no use to him, but in few cases would anybody feel certain that the development of the next half century in both mathematics and engineering science would not make even those branches quite useful to him. Some branches he may not have occasion to use at all for years and then he may have work to do in which they are indispensable. I would, therefore, suggest that branches like geometry and trigonometry, which are of instant use, should be taught quite thoroughly, but that only the elementary principles of the least useful branches be taught but taught carefully, so that the engineer will be able to go into the subjects more fully if occasion requires. Some branches that are seldom studied by American engineers are used quite freely by European writers on engineering science. It is not fair to the future American engineer to thus deny him access to the best European technical literature.

A reasonable insight into the methods and scope of some branches of modern mathematics would, I think, be worth while. There are numerous problems in engineering science that have thus far baffled the mathematicians. It is quite possible that some branches that are at present looked upon only as mathematical gymnastics will eventually be used to solve those very problems.

Many mathematicians have a horror of approximate solutions. Cases frequently occur in which these answer the purpose perfectly.

Professor D. C. Jackson: Two suggestions in the remarks made indicate tendencies. How about thinking about them a little, and considering the desirability of these things as policies? Professor Chatburn said he "wrote letters" to the heads of other departments and asked them for suggestions. Professor Plant said he "feared" the consultations which occurred while the teachers were crossing the campus.

I feel sure that if Professor Chatburn had made his inquiries by conversation instead of by letter, he would have obtained some important answers. We are, in each institution, working together collectively, not individually, trying to do uniform work, and work which is worth while; and one does not get the best results under such circumstances by writing letters to each other. If the men in the electrical engineering department want to consult with the men in the mechanical engineering department in regard to whether mechanics or steam engine laboratory is being properly taught, the best results are obtainable only by getting over and talking with them. We can well afford to talk on the streets and at lunch and at other times, but refrain from writing letters; because we must recognize that the thing becomes too rigid and non-mutual under the practice of letter writing.

Of course, all of us will write letters to our colleagues in the same institution, but they are used rather as memoranda of what has been agreed to or has been said in the way of suggestions that may be taken up, rather than for the actual formula of a conference.

I was a little shocked at Professor Plant's implication. I suspect he meant talk that comes to nothing; but the implication that he believed informal conferences and conversations are not effective seems unfortunate.

Another tendency was that presented by Dean Ketchum. Perhaps in his situation it is all right, but I have always believed that the electrical engineering department should teach electrical engineering and teach it just as well as it knows how; and that the mechanical engineering department should do its part with mechanical engineering and each keep its hands off the other fellow's subject so far as attempting to teach it is concerned. No one set of men can become competent to teach all the branches of engineering. Correspondingly, the economics department must teach the economics and do so in such a way as to make it thoroughly simple to engineers. Perhaps no one knows what economics is, to be sure, but it is up to the professor of economics to prove that he is right in his teaching processes. If he can not so prove, it is our business to try to get the president to appoint another professor of economics—all in gentlemanly fashion, to be sure. This problem was satisfactorily cared for some years ago at the University of Wisconsin by the appointment of the late Dean Johnson of correlating committees.

Dean F. L. Bishop: I would like to yield two minutes to Professor Jackson and have him tell us of the coördination which exists in the Institute of Technology at Boston, between mathematics, physics, mechanics and chemistry.

Professor Jackson: As far as coördination between these departments is concerned, I will say that it is very loose. It is, however, not as loose as Dean Bishop thinks it is, because the engineering departments put pressure on the other departments to do things in certain specific lines; and when the other departments can bring convincing arguments to bear to show that what the engineers are asking for is foolish or impracticable or not for the best, the engineering departments yield. But pressure is being put on them to do things the engineering departments want. That holds them to coordination. They put up a battle, of course, if the thing is not what they think is right. If the engineers ask for foolish things, it is their business to resist to the uttermost. On the other hand, it is the engineer's business to force things upon them by insisting upon good pedagogical results. It brings good returns.

President C. S. Howe: I wish to call Professor Jackson's attention to the fact that he can not get rid of the professor of economics. If he does, he will have the Association of College Professors after him.

I have been very much interested in what the committee has said, because it is the subject to which I have given some consideration for many years. Some twenty years ago I called upon the head of every department, asking them to suggest possible improvements in mathematics. We found this course very helpful, and followed it at Case School for many years. It did not seem, however, to be sufficient to cover the ground. During the last year we have had several faculty conferences. Each professor has been asked to criticize the work of every other department, so far as it is related to his work; and I may say that we have had some very interesting meetings. There have been a great many criticisms. These have been made kindly, but firmly; and I think every member of the faculty has derived a great deal of benefit from them.

Professor E. R. Hedrick: What Professor Jackson has said shows that, after all, in reality coördination between the departments is necessary for successful work. I think it also illustrates the fact that the mere fact of getting a department of mathematics into the school of engineering is not going to solve the difficulty. They have all the departments in one school at the Massachusetts Institute. Has that solved the difficulty? Not for a moment.

It seems to me that this puts the situation right back where the Committee wanted to put it. It shows the necessity of some kind of coördination between the different departments. It emphasizes what Dr. Mann spoke of last night when he said that we had developed a kind of senatorial courtesy among the departments, with the result that there is too much feeling that each department is a law unto itself. We must get over this feeling, and we must realize that things carried on in one department are the business of every one of the other departments.

What the Committee wants is to have this Society go on record as advising the various schools to try to have that kind of contact between the various departments, to break down the walls of tradition and false courtesy between the departments, to such an extent that we can have some real co-operation, so that we shall quit teaching, as is sometimes done, the very same topic in at least three different ways. There is nothing that is harder on the student; there is nothing that results in greater confusion than our present process in most schools of allowing total independence on the part of each department. I for one hope very much that the Society will do as the Committee has suggested. I should like to move that the Society go on record as advising and urging the formation of such committees in each of these institutions.

Requested to make his motion more clear, Mr. Hedrick spoke as follows:

I should like to make this motion broader than the report of the Committee would indicate, to have all those departments represented which are fundamentally interested. I think that ought to be left to local conditions to some extent; and certain other features should also be left to local conditions. For example, the number of such a committee would have to be left considerably to local circumstances. I admit also that there are institutions in which the tendency I mentioned toward extraordinary courtesy would persist.

I should, then, word the motion as follows: The Society advises and recommends to the various institutions that they attempt to form conference committees, on which there should be representatives, at least of the departments of mathematics, physics, and mechanics, and also of such other departments as may be interested."

I think we cannot make it too definite, because of the differences in local conditions. Motion carried.

Professor L. C. Plant: I wish to say, Professor Jackson, that my remarks with reference to the meetings of men and the discussing of particular subjects as they cross the campus were not intended to discourage such discussions. They are very good, indeed, but they should be carried further. In order to make myself clear, I want to say that I spent almost three hours recently with the professor in thermodynamics, going over the entire subject with him, he pointing out the things he wanted the students to know when they come to him. We attempt to embody his suggestions in the work we are doing.

I also wish to make this statement. I believe that the Committee had in mind this thing with reference to knowing what the other departments are doing; that it is not enough for the mathematics faculty, for example, to know mechanics and physics. They should know the methods of presentation, more or less, as well. Suppose the work in these departments is developed along the line of vectors. If you know that, you can direct your courses better to prepare the student for that particular development.

One remark concerning the attitude brought out by Dean Ketchum, I have my doubts about the wisdom of the engineering department saying, "Now, if this is not done as we would like it, we will form a separate department of our own." Those of us who have had considerable to do with mathematics know how poorly prepared engineering students are to teach mathematics. An engineering training furnishes an excellent foundation for the teacher of mathematics but it comes far short of equiping him. The teacher of mathematics must know his mathematics and then he must be so enthusiastic over its applications that he creates in his engineering students a real desire to know the subject. I would like to leave this thought with the Society: the teacher of engineering students should know his subject—he can not be expected to be a specialist in several subjects, but his sympathies toward the other subjects in the curriculum should be such that he will make every possible point of contact between his subject and the other subjects of the curriculum. When this is done then there is no need for creating separate departments of mathematics, English, and so forth, for engineering students.

In way of information, I might say that our questionnaire was a rather short one and it might be gratifying to the Society to know that practically every person who received a copy of that questionnaire responded.

REPORT OF THE COMMITTEE ON TEACHING PHYSICS TO STUDENTS OF ENGINEERING.

Committee No. 11.

BY DAYTON C. MILLER.

The Committee on Teaching Physics to Engineering Students made a preliminary report at Princeton, and a further report of progress at Ames. It was decided that it was not desirable to prepare a syllabus of physics, since the content of a general course seems to be well established. The Committee felt that it was expected to make recommendations for increasing the efficiency of the teaching of physics, and it was decided, therefore, to use the questionnaire method, in an effort to obtain definite information regarding the current faults and proposed remedies.

The questions suggested at the Ames meeting were submitted, by mail, to all members of the Committee for revision, and later the three questionnaires printed in the *Bulletin* for June, 1916, were sent out to 1,001 members of this Society, being distributed as follows: Questionnaires *A* and *B* were sent to one teacher of physics in each of 63 different institutions; questionnaire *B* was sent to 629 teachers of various branches of engineering in 101 different institutions, and questionnaire *C* was sent to 309 practising and consulting engineers not directly connected with teaching institutions. Answers have been received from 92 per cent. of the physicists, from 15 per cent. of the engineering teachers, and from 7.7 per cent. of the practising engineers; the number of replies from physicists is all that could be hoped for, but the lack of interest on the part of practising engineers is disappointing.

Perhaps it is unfortunate that the questionnaires were sent only to members of the Society, as is usual; while teachers of engineering may be well represented in the membership, the representation of physicists and of practising engineers is not so good.

The questionnaires were addressed to individuals and not to institutions. While many of those sending replies are no doubt willing to announce their names, yet a considerable proportion wished their identity to remain unknown. Undoubtedly the answers would seem more interesting if not more valuable, were the personal element included. There can, however, be no harm in naming the institutions represented. Replies to the questionnaires have been received from one or more teachers of physics or of some branch of engineering. from the following institutions, 101 in number (for brevity, the word university, college, etc., is not repeated in many of the names); Universities—Akron, Brown, Bucknell, Cincinnati, Chicago, Columbia, Cornell, George Washington, Harvard, Johns Hopkins, Marquette, McGill, New York, Northwestern, Pittsburgh, Princeton, Purdue, Redlands, Rochester, Southern California, Stanford, Toledo, Tulane, Vanderbilt, Washington and Lee, Yale. State Universities of—Alabama, Arizona, Arkansas, California, Colorado, Florida, Idaho, Illinois, Iowa (Iowa City), Iowa (Ames), Kansas, Kentucky, Maine, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Carolina, North Dakota, Pennsylvania, Ohio, Oklahoma, Oregon, Texas, West Virginia, Vermont, Virginia, Washington (State), Wisconsin, Wyoming. Colleges—Clemson, Colorado, Dartmouth, Haverford, Highland Park, Lafayette, Pennsylvania (Gettysburg), Pennsylvania State (State College), Rhode Island State, Rutgers, South Dakota State, Trinity, Tufts, Washington State. Miscellaneous—Brooklyn Polytechnic Institute, Carnegie Institute of Technology, Case School of Applied Science, Clarkson School of Technology, Colorado School of Mines, Drexel Institute, Massachusetts Institute of Technology, Michigan College of Mines, Rose Polytechnic Institute, Stevens Institute of Technology, Throop College of Technology, United States Naval Academy, Virginia Polytechnic Institute, State Agricultural College of Colorado, Georgia School of Technology, Michigan Agricultural College, Mississippi A. and M. College, New Hampshire Agricultural College, New Mexico College of A. and M., South Carolina Agricultural College, A. and M. College of Texas, Nova Scotia Technical College.

The replies to the various questions have been tabulated and summarized, and the conclusions which may be drawn will be explained in detail.

QUESTIONNAIRE *C*.

Answered by Practising Engineers.

By means of questionnaire *C* it was hoped to obtain the opinions of practising engineers regarding the teaching of physics. While answers have been received from only 24 persons, yet many of these are eminent professional engineers and occupy important official and public positions.

1. *What are the criticisms of the teaching of physics, as observed by you?* Fifty-two per cent. of the replies contained no comments on this question; the criticisms of the others are more or less general in character, and for convenience in this report they have been combined with the answers to question 5 (*d*).

2. *Do you think the amount of laboratory work, as usually given, is sufficient?* Sixty-two per cent. of the practising engineers vote that the time generally allowed for laboratory physics is sufficient.

3. *Should the calculus methods be used in general physics courses?* Sixty per cent. of the practising engineers say that calculus should be used. Individual opinions are:

No, because calculus is poorly taught.

Calculus greatly simplifies the subject and gives the student a clear understanding of physics.

The physics course should be physics and not mathematics.

I am very strongly of the opinion that if we are talking about the department of physics as differentiated from the physics of other departments, such as mechanics, then I believe that the emphasis should be laid upon the physical concept rather than upon the mathematical demonstration.

4. *Are the mathematical and theoretical aspects of physics of value to the engineer?* Ninety-five per cent. of the practising engineers vote "Yes," with emphasis.

5. *In the light of your experience, what changes would you think desirable in the education of the engineer as to:*

(*a*) *Time spent in studying the fundamental sciences as compared with time spent in studying the technology of engineering.*
(*b*) *Method of presenting work in physics.*
(*c*) *Subject matter taught in physics.*
(*d*) *Other items relating to this general subject.*

(*a*) One hundred per cent. of the practising engineers vote that more time should be spent in studying the fundamental sciences. Various individual opinions are as follows: The best results will be obtained by teaching soundly the fundamentals, such as the natural sciences, mathematics, and languages.—Science is fundamental, technology should be used only for illustration.—Give maximum time to fundamentals; technology will be readily acquired later.

(*b*) There are no definite criticisms of the methods of presenting work in physics except such as are noted under (*d*).

(*c*) There is a general request for an increase in the subject matter relating to the fundamentals of physics.

(*d*) Many interesting remarks were made under this number, some of which are as follows: The strongest impression I have gained from experience with many college men is the lack of full understanding of simple and fundamental principles; it isn't uncommon to find a man who remembers a catalog of engineering facts but falls down on relatively simple problems, because he lacks knowledge or faith, of simple laws, such as the conservation of energy.—The greatest technical deficiency of young engineers is in connection with applied mechanics.—More systematization is needed in teaching physics.—The student looks upon college physics as a supplementary high-school course: he does not realize that all engineering is built upon four fundamental courses of mathematics, physics, chemistry and mechanics; for this the student is not to blame, the engineering professor fails to inform him properly.—Engineering courses as a whole err greatly in too much technical specialization; I hope the day will come when all colleges will have a four-years course in engineering, without classification, with added graduate courses of one or two years in which special courses are taught; I would double the time spent on mathematics, physics, chemistry, and mechanics.

Keep putting the students to the test! There is no use in taking up advanced matters until the student can actually handle the fundamentals with real intelligence.—In a college course in engineering, we should constantly keep in mind that the man who graduates will still have to learn his profession as a specialist after graduation.—Courses and methods should vary to suit the student's individual aptitude; there should be a general course which everybody can pass, and further courses for those who can pass them easily; those who cannot should not be made to pass in spite of inaptitude. —Civils should not be compelled to waste their time on such topics as electrical theories and measurements or entropy and allied subjects.—One of the greatest mistakes made by colleges is allowing instructors who have simply made rank in their courses to take up on graduating the teaching of students, without practical experience and without knowledge of the principles of teaching or of class-room work except as practised upon themselves; in some cases this amounts actually to cheating the students.—I believe the fundamental sciences should be differently treated for different engineering groups; more of the historical side of the evolution of physics should be given to bring out the essentials of original research; a practical attitude should consider accident prevention, or the danger involved in the disregard of physical laws.—An excellent textbook should be used and the professor should spend a goodly part of his time in lectures, laboratory should be collateral to this; practically no time should be given to teaching technical applications; the man who is firmly grounded in a few of the fundamentals has an excellent basis for further development.—College training should deal thoroughly with fundamentals, and in a descriptive and inspirational way with engineering technology; fundamentals can be learned readily in college and with difficulty afterwards, while the reverse is true with respect to engineering technology.

Teaching of physics is not practical; too much ground is covered; material given on electrostatics, electricity, magnetism, etc., is usually not understood by the instructor, this material should be omitted entirely from physics designed for engineering students. Hours are spent in studying calculus, physics, machine design and other technical subjects, where minutes are spent on English: in proportion to their importance after graduation this order of things should be reversed.—Correct theory is always of value, and if theory is mastered, practice must necessarily follow; fundamental sciences should not be neglected for specialization in any line, for so much that is met with later must go back to fundamentals for solution.—Too often the teachers are narrow specialists, possessing little knowledge outside of their limited field, and their experience is confined to the class-room, laboratory, and the social activities of the college campus and some religious organization: and their outside reading frequently consists of such material as popular novels, a local daily, the sporting news, and The Ladies' Home Journal.

Teachers should be men of broad knowledge and wide practical experience, capable of giving illustrations of the application of scientific principles, and thus greatly stimulate the interest of the student. Get the student into the habit of thinking, he is educated only in proportion to his ability to think. A final examination which cannot be given, permitting the student free access to all the volumes of a library, is worthless.—Physics is one of the fundamental sciences for the electrical engineer, and the more the design engineer, the works engineer, and the commercial engineer know of physics, the better able will they be to answer the many questions which arise in connection with their work. The mathematical and theoretical aspects of physics are of great value to the engineer; we would rather have the college man study the fundamental sciences very thoroughly, than to specialize along some line of engineering.—The instruction is too "scholastic."—The teacher gives too little time to his classes.—The instruction is too dry and lifeless; it should encourage the student to think, question, and investigate.—Too much ground is covered.—Too much lectures; too much recent theories; too much use of the metric system; too many useless terms, as the poundal, slug, etc.; lack of experiments on heat.

The application of fundamental physical laws such as the law of conservation of energy to engineering problems presented by a slab or beam in bending should be taught and understood by all students. A so-called research fellow in one of our leading universities, testifying in a recent patent suit, could not conceive of any relation whatever between the external work of the loads and the internal work of deformation in a concrete slab. Two professors of civil engineering, one a dean, could not understand why a slab not thoroughly hardened in the interior should give any greater deflections in this condition than it would give when curved throughout. Thus we have a dean in an engineering college so lacking in familiarity with the principles of physics that he did not understand the part horizontal shearing rigidity plays in the static balance in opposing external work by internal resistance. The manner in which energy of internal work is stored in an elastic structure should be taught in the course in physics to the engineering student, yet there is not one graduate out of fifteen who seems to have any clear-cut ideas of this subject and many of those teaching it are equally lame.

QUESTIONNAIRE *B*.

Answered by one teacher of physics and teachers of various engineering subjects in each college.

Questionnaire *B* was designed to furnish information in regard to certain specific matters relating to the teaching of physics, as viewed by the teacher of physics, and by the teachers of various branches of engineering in the same institutions.

1. *Should instruction in general physics include such subjects as dimensional equations, black-body radiation, radioactivity, X-rays, etc.?*

The answers have been analyzed to show the affirmative vote of the physicists from fifty-seven institutions, the engineers from the same institutions, engineers from other institutions, and the averages of all votes.

	Dimensional Equations.	Black-body Radiation.	Radio-Activity.	X-Rays.
Physicists	60%	67%	74%	80%
Engineers in same institutions	55	58	58	55
Other engineers	50	48	56	56
All votes	54	57	03	63

2. *Do your students in engineering take advanced courses in physics in addition to the regular prescribed courses? What is the attitude of the engineering faculty in the matter?*

Advanced courses are taken in 27 per cent. of the institutions, while 80 per cent. of the physicists and 40 per cent. of the engineers vote in favor of such courses. The reason almost invariably assigned for a negative vote is that there is no time that can be given to advanced courses.

3. *Should calculus be a prerequisite to the course in general physics? Should calculus methods be used in the instruction in physics?*

Of the teachers of physics, 31 per cent. think calculus should be a prerequisite to the course in general physics, and 45 per cent. think calculus should be used in the course; 36 per cent. of the teachers of engineering think calculus should be a prerequisite, and 60 per cent. think it should be used in the course; 60 per cent. of the practising engineers vote for the use of calculus in teaching physics. The remarkable feature of this vote is that 60 per cent. of the practising engineers think calculus should be used in physics, while 55 per cent. of the teachers of physics think it should not be used. The reason assigned for not using calculus is that it is impracticable to arrange the schedule so that calculus can be taken before physics.

4. *Should different courses in physics be given to different groups of engineers, as architects, electrical engineers, etc.?*

Eighty-seven per cent. of the teachers of physics and 85 per cent. of the teachers of engineering vote against differentiation. The opinions on this question are very emphatic: Yes; sound is more important to an architect than to an electrical engineer. —I strongly favor the giving of different courses.—No; the best course in physics is none too good for any of them, and each deserves the best.—Decidedly not!—There is some sense in segregating boys and girls in high-school physics, and general students from engineers in college, but none in segregating the various groups of engineers; there is enough probability that they will be narrow, without encouraging it.—Physics should be studied as a science with especial reference to physical explanation of phenomena, and not as a mere vocational subject.—On no account! The student should know the physicist as such, and become informed of the things that the physicist has uncovered; the work should be subjective, staying just as close to nature as possible, omitting as little as possible.

QUESTIONNAIRE *A*.

Answered by teachers of physics.

Questionnaire *A* was sent to one teacher of physics in each of 63 different institutions, and answers were received from 57 of them.

1. This question related to entrance requirements in physics and mathematics and the answers have not been analyzed, since they are hardly complete enough to give useful information.

2. (*a*) *What is the minimum time given to instruction in physics, by lectures, by recitation, and by laboratory practice?* (*b*) *In what year does this work come?* (*c*) *In the light of your experience do you recommend a different schedule?*

The purpose of this question was to ascertain with how little physics a student may be graduated from any course in the engineering department of a college. Most institutions, as shown by Question *B–4*, give the same amount of physics to all, while in a few cases there is great variation in the amount required. Three institutions report that students may be graduated who have had only 4 semester-hours of lectures and recitations and 4 semester-hours (actual time) of laboratory practice; and in one instance only 2 actual hours per week for one semester is required in the laboratory. Thirteen colleges require 6 semester hours, or less, of lectures and recitations, while 21 colleges require 10 semester-hours or more. Of the thirteen colleges requiring six semester-hours or less of lectures and recitations, two are in Ohio, one in Indiana, and the others are in the southern or far western portions of the country. Sixty per cent. of the institutions are satisfied with their present schedule arrangements, which, on the average, allow 9.3 semester-hours for lectures and recitations and 7.5 semester-hours (actual time) for laboratory practice. Forty per cent. of the colleges wish an increase in time, the average at present being 7.5 semester-hours for lectures and recitations, and 7.9 semester-hours (actual time) for laboratory.

The instruction in general physics is given in the sophomore year in 58 per cent. of the institutions; 22 per cent. give the instruction partly in the freshman and partly in the sophomore years, and 20 per cent. give it in the sophomore and junior years.

3. *Do those who have had preparatory physics take courses different from those who have not? Does preparatory physics materially help the student's progress?*

Seventeen per cent. of the institutions give a different course in physics for those who have had preparatory physics, from the course given for those who have not. Seven and seven-tenths per cent. say that the preparatory course is beneficial, though this sentiment is very mildly expressed; one single report says that the preparatory course retards the student's progress.

4. *How is the time given to general physics divided between the various sections of the subject?*

Only about one third of the answers to this question were definite; there seems to be a fair agreement in the general practice, and this is represented by the treatment of the common text-book. The average percentages of time given by the definite replies are as follows: mechanics 30 per cent.; heat 16 per cent.; sound 6 per cent.; electricity 32 per cent.; light 16 per cent. Five institutions state that no time is given to sound, and three give no time to light.

5. *In case your institution has an academic department, is physics (for engineering students) taught in it or in the engineering department?*

In 21 per cent. of the institutions physics is taught in the engineering department as distinguished from the academic department of physics.

6. *What steps are taken to secure continuity of subject matter between physics and the several subsequent engineering departments for which physics is supposedly a prerequisite?*

In 60 per cent. of the institutions, some effort is made to secure continuity between the subject of physics and the following engineering courses. There seems to be no definite method of securing this result except such as is described by the words "consultations," "conferences," "correlation," etc. Forty per cent. of the institutions report that no organized effort is made to secure continuity.

General Recommendations.

The study of these questionnaires leads the Committee to make the following general recommendations as tending to the highest efficiency in the teaching of general physics to engineers. The Committee appreciates the fact that some of these recommendations are inconsistent with existing conditions at certain institutions, and that under these special conditions other specifications may be more acceptable.

1. Preparatory physics should be required for entrance upon any engineering course.

2. The course in college general physics should be the same

for all groups of engineering students, and it should be under the supervision of the general department of physics of the college or university.

3. The increased use of higher mathematics in developing the fundamental theory of general physics, including the use of the methods of elementary calculus, will be advantageous to the engineer.

4. In order to secure the benefits mentioned in paragraph 3, the course in physics should not begin till the student has had training in elementary differential and integral calculus. As the schedules are ordinarily arranged, physics would then begin about the middle of the sophomore year. It is usually thought best to begin physics with the sophomore year, sacrificing the advantages to be gained by the use of the calculus. To begin physics in the freshman year would still further sacrifice the use of mathematical principles, and this should be avoided. It is possible that a rearrangement of mathematics schedules will make elementary calculus methods available at the beginning of the sophomore year, a condition much to be desired.

5. The minimum time suitable for the course in general physics is 10 semester-hours for lectures and recitations, accompanied by 9 semester-hours (actual time) of correlated laboratory practice.

6. The course in general physics should cover the entire subject matter, including sound and light. Such subjects as dimensional equations, radio-activity, black-body radiation, X-rays, etc., should be included, but should be treated very briefly. The greatest emphasis should be placed upon the obvious fundamentals of the science, and the technology should be used for illustration.

7. The course in physics should be correlated to the work of the preceding courses in mathematics and to the following engineering courses by definite methods adapted to particular faculty organizations.

It would be very beneficial if the time given to general physics could be greatly increased, and if the instruction could begin at the middle of the second year and extend through the third year. In this scheme, calculus could be a prerequisite to physics, and calculus methods could be used in physics, which would facilitate the work, and would tend to make a more powerful analytical engineer, one who could *use* higher mathematics as a real, working tool. This suggestion might be practicable only with a five-year course for engineers. There is reason to think that the present educational tendency is in this direction.

The practising engineers are very emphatic and almost unanimous in their appreciation of the mathematical and theoretical aspects of physics, and they urge in the strongest terms that more time be spent in studying the fundamental sciences even at the expense of time now given to the study of the technology of engineering.

The Committee hopes that these results will be of some influence in the rearrangement of schedules whereby physics may be given a better opportunity to prepare the students for engineering work; and the more so, since the deficiencies in physics seem to be largely due to the lack of sufficient time for the proper mastery of so broad a subject.

Dayton C. Miller, *Chairman,*
William S. Franklin,
G. A. Goodenough,
F. K. Richtmyer,
R. M. Bird,
J. H. James.

Discussion.

Professor O. M. Leland: I should like to ask Professor Miller if in sending this questionnaire to practising engineers he took into consideration the branches of engineering which these men were practising?

Professor D. C. Miller: I sent to engineers in all branches of practise. We took all who were on the list of members of this Society.

Professor Leland: It occurred to me that electrical engineers, for instance, might have different views regarding the mathematical theories of physics from those held by civil engineers.

Professor E. R. Hedrick: If we can get into action the various committees mentioned under a previous report, it seems to me such a joint committee might also attempt to see if we could not in some fashion organize departments of physics and mathematics in such a way as to make it possible for the Committee on Physics to coöperate with the Committee on Mathematics. If the two departments could get together, it would be easy enough to know when to introduce topics in one department which affect the other.

Professor F. C. Caldwell: A point suggested by the first speaker is of great interest; namely, the attitude of practical men in different lines of engineering toward the fundamental sciences in general, and physics in particular. For example, the attitude of electrical engineers seems different from that of civil engineers; and electrical engineering courses, as a rule, are much broader in the way of fundamentals and especially have a great deal more physics than the courses in civil engineering. It would seem that a study of the problem from this point of view would be interesting.

I should also like to bring out, in connection with what Professor Hedrick has said, the importance of having physics co-ordinated with mathematics so that the students will have a working understanding of the use of calculus in solving physical problems.

Professor Wm. Kent: I would like to call the attention of the Committee on Committees to the uselessness of the methods, or the inefficiency of the methods, of our getting information into the Society. We appoint a Committee on Physics, to do something. So far as we know, after one year they have published a questionnaire. They sent out one thousand questionnaires, and received answers; and the results are presented in manuscript form, so that it is impossible for us to discuss them. Is that the way we should work?

Professor H. S. Jacoby: Inasmuch as the recommendations before us represent only the opinion of the chairman, the report is not in a condition to come before the Society for any action whatsoever. It is practically a progress report.

Professor A. M. Greene: It has pleased me very much to see in this report that most people do not desire a different type of physics for the engineer. I do not like the term "engineering" physics or mathematics or English. I think we should learn physics, mathematics, English. I do not believe that we should limit training in mathematics to just the problems which are to follow. If physical or mathematical training is just limited to courses in technology which are to follow, the engineer will be a very narrow man, and problems will arise which he will not be able to solve. So I am very glad to see that the large majority of votes are in favor of physics rather than "engineering" physics.

Professor Kent: The professor of engineering should have a good deal to say about what the professor of physics is doing with the time he has for instructing engineering students in elementary physics. I think instruction in physics for engineers should include fundamental mechanics and volts and amperes, and the time which ought to be devoted to these things should not be spent on electrons and ions and other things which seem immensely important to a few people, but not to engineers.

Mr. Willis Whited: I think physics should be taught as a science and the students thoroughly grounded in the fundamental principles, utilizing the advanced work to illustrate and enforce the principles. The selection of the branches to be omitted is a very delicate matter, and I think those charged with that duty should bear in mind that their students will be the engineers of the next half century, and that engineering is in a state of constant progress; in fact it has been largely made over two or three times within the last forty years and the same thing may happen within the next half century. Forty years ago electricity was not taught to many except to prospective telegraphers. The vast majority of students will never understand a branch of science unless they learn at least the rudiments of it at college. Scientific principles, if thoroughly established, are the same yesterday, today and forever. Engineering practise changes almost from day to day and from house to house. Your students of today will have to compete with the engineers of thirty years from now.

Professor W. T. Magruder: I understood the chairman of the Committee to urge that the minimum of time should be ten semester credit hours for classroom work, and nine for laboratory. How common is that in American engineering colleges today?

Professor Miller: I gave the average as over nine hours of recitations and over seven of laboratory practice.

Professor Magruder: Is not your minimum more than the average?

Professor Miller: Yes; but I was trying to meet the criticisms which were made.

Professor Magruder: I understand that that is the minimum to be given to all engineering students?

Professor Miller: Yes.

Professor Magruder: It is interesting to note the point of view of some of the speakers. Professor Jackson is from an Institute of Technology. Professor Greene comes from a Polytechnic Institute. Neither of these gentlemen are connected at present with state universities, as each of them used to be. I would like them kindly to remember the time when they were in state universities, and it was necessary to teach physics to agricultural, arts, medical, and other students in large variety, as well as to engineers, and hence the necessity of having a variety of courses in physics in a large, general university.

Again, on account of the variety of engineering curricula offered by our engineering colleges, it would seem to be a little difficult to have a standard course in physics for all engineers. For example, the architects want little, if any, physics; the architectural engineers want more; and the electrical engineers want most. As the whole class has to be divided into many sections, it would seem to be logical to treat these sections differently and particularly as to giving a minimum of what may be called "cultural physics" to all and emphasizing the particular variety of technical physics to those who so need it.

We engineering educators must be governed somewhat by the opinions of our professional brethren. For example, it is questionable if the faculty of an engineering college should go absolutely contrary to the recommendations of the Committee on Education of the American Institute of Architects. It might be better first to have a discussion with them on the subject of the amount of physics which students in architecture and architectural engineering should have.

Dr. C. R. Mann: An interesting fact was brought to my attention not long ago with regard to physics. I had occasion to compare the time devoted to physics in 1870 in engineering schools with the amount devoted at the present time in one or two schools. I was very much surprised at the result. It appeared that the amount of time devoted to physics had remained constant at twelve semester hours, whereas the amount of time devoted to chemistry had increased from six to fourteen hours.

Professor Jackson: I would like to ask Dr. Miller to answer a question. Why does he say we should never start physics earlier than the opening of the sophomore year? Professor Magruder intimated that I had forgotten my experience in the University of Wisconsin. I might suggest that at the University of Wisconsin we had different men teaching engineering physics from those who taught physics in general. But I believe the man who teaches the physics should be in the physics department, not in an engineering department.

Professor Magruder: Do you not have men in economics and in mathematics in the Institute of Technology, and not at Harvard? If the Institute of Technology and Harvard were all one institution, you would possibly have to send to Harvard to have the students taught English, mathematics, economics, and the rest.

Professor Jackson: I think such a course would be desirable if the two institutions were one. It would be our business then to see that our engineering students were properly taught by those other departments, if we had enough sense and judgment to see to it. As it is, of course, the Institute of Technology is so large that it has a large mathematics department, and therefore has some very able mathematicians. I think the condition of our teaching in that department is as satisfactory as at Wisconsin.

REPORT OF THE COMMITTEE ON ENGLISH.

Committee No. 12.

BY C. W. PARK.

I know it is customary to begin a report with explanations, if not with apologies. I feel that it is necessary in this case, especially, to explain the circumstances under which the report has been gotten up and presented.

Professor Earle, who is chairman of this Committee and who, as we all know, has been both a pioneer and a missionary in the matter of teaching engineering English, has been ill during the greater part of the second semester of the past year. Notwithstanding this fact, he has generously undertaken to do the largest share of the work himself. The report which he was able to get together for publication in this issue of the *Bulletin,* which you have in your hands, was not so complete as he had wished, but since the purpose of the Committee in its first year was to obtain a preliminary survey of the field, we feel that something has been accomplished, meager though the returns have been and vague though many of the answers have been.

I might explain further that I was not originally on this Committee. I believe it was intended that I should be; but a confusion in initials resulted in the fact that I did not know until a good part of this work had been done that I was a member of the Committee. I say this in order that I may receive no credit for the work that appears in this report; because I assure you that I had nothing to do with it, except filling out a single questionnaire which came to our institution. Since that time I have been very much interested in making a belated examination of the material compiled by the Committee, and have noted a number of interesting things which I believe Professor Earle still has in store, to present in more definitely tabulated form than is given here.

In regard to this questionnaire, as Professor Earle has explained, the Committee was reluctant to adopt the questionnaire method. This method has become so common as a means of obtaining information that it is now considered a great nuisance. In the second place, makers of questionnaires are suspected of framing their questions deliberately in order to catch a certain kind of answer, and I have been gently reminded that one of our questions presupposes a favorable reply.

It is true that the first question the Committee has asked, "In what sense is English a fundamental subject," rests upon the assumption that English *is* a fundamental subject. We may take that for granted, however, not merely because English is so classified by this Society, but for other excellent reasons. This assumption, of course, needs no defense from the standpoint of the teacher of English; and I believe also, from the standpoint of the majority of technical men, if the indications during the past two or three years are to be trusted. We recall any number of discussions in technical magazines; we recall the findings of Dr. Mann, reported last year, which also pointed in this direction. In theory, at any rate, there is a general agreement that English is fundamental.

The answers to the first question seem to be reducible to about these three divisions: English is a fundamental subject in the first place, because it is a *necessary tool,* an indispensable means that the engineer has of expressing his ideas; and especially important as a means, because it is more universal than the language of blueprints, curves, and other methods of conveying engineering information. In the second place, English is fundamental, most of the replies indicate, because it affords *training in thinking;* because by means of a person's English you can tell whether or not he has caught the idea—or, to put it in the language that we heard in the interesting discussion last night, whether or not he has been able to "think straight."

A third reason why English is regarded as fundamental may be put, perhaps, like this; that in technical colleges, English is the last stand of the humanities. A great many students enter the college with little training in the old-fashioned humanities, as they were called; and so about the only human subject in the curriculum is English. A number of persons have expressed not only the conviction as a matter of theory, but the conclusion as a matter of experiment, that English can be made a clearing house for the human side of engineering education, as well as a tool of expression and a means of discipline in thought. A few figures may be noted under 1, as follows:

Topic No. 1.

	Yes.	*No.*
In your course for students of Engineering, is English fundamental in theory and practice?	19	5
Is English given the same weight in promotion as such subjects as mathematics?	22	3
Is the importance of good English stressed by various members of the faculty in their class work?	14	3
Have teachers of English equal standing with other members of the faculty? (Question slightly changed in form.)	12	1

I shall pass very rapidly over the details of the remaining answers, because I know that figures are tedious, and I shall simply indicate the principal conclusions. One thing that falls under the second topic is the matter of the time or opportunity given for engineering English. Upon examination of the schedules—this was entirely distinct from the questionnaire, by the way—in the various colleges, it was found that only a limited amount of time is given to required English, and that a comparatively small amount of time is given to elective English. As regards the electives, the situation is not so satisfactory as it might appear. For instance, nine schools out of twenty-six offer no elective courses in English; the remaining seventeen in one group examined offer electives in one or more of the following courses: English literature, business English, advanced English, and public speaking.

Only two institutions report many takers for these elective courses. The others state that because the schedules are already crowded, it is not possible for many of the students to elect courses in English.

One school was a striking exception to this rule, however; so striking that I want to give the figures. They offer as electives in this institution eight writing courses and nine reading courses in English, for engineering students; and 576 students are enrolled in these various courses.

The next question has to do with the relations between the English department and the other departments. There seems to be a disposition in many cases to regard the separate divisions of a college as watertight compartments, so to speak, with no connection expected or permitted between English and chemistry, for example; and a distinct separation among all the different departments. The attitudes reported as between the instructors in English and the instructors in other departments extend all the way from open hostility in a few cases, to entirely sympathetic coöperation in others. One professor of English who was asked to discuss this questionnaire, or to send a discussion to this meeting, illustrated pretty well, I think, in his reply, the hostile attitude. He said, concerning the discussion of this report: ''We are not at all interested in carrying the war into the enemy's country, but we are ready to defend ourselves when attacked.'' So the English department in that college remains on the defensive. As Professor Earle put it, there is an armed truce at that institution between the English department and the technical departments.

Between the two extremes of hostility and sympathetic coöperation is a sort of mild tolerance of one another's existence, that is about as unfortunate as open hostility, because it represents indifference regarding the whole question. One institution reported something like this: ''We have not very much to do with English, and trouble ourselves about it as little as possible. We send our students over to the college of liberal arts, and they give them a few hours a week for one year, and we call it quits.'' This explanation was typical of a larger number of replies than one could wish.

No coöperation	3
Very little coöperation	4
Some coöperation	4
Considerable coöperation	6

Many did not reply.

I shall pass very rapidly over the next series of questions, because they have to do with methods of instruction in engineering English, and I think it is unwise and unnecessary at this time to trouble technical men with questions of this kind. I believe a part of the Committee's work during the next year will be to tabulate the principal methods, and put them in sufficiently specific form that they may be appropriated, where that seems advisable, by institutions not now using them, and where they may be criticized conveniently by technical men whose judgment, of course, is wanted on all these questions.

The last part of the questionnaire corresponds so closely to the first part that it may be dismissed, I think, in a word. You will notice that if you ask what are the aims and results of your instruction in English, and what do you consider the ultimate purpose of instruction in English, you are getting back to the question, ''Do you consider English a fundamental subject, and why?'' It seems to me that this latter part is justified, rather because it approaches the subject from a somewhat different angle than because it forms a new division of thought.

To the last question, ''What is the judgment of the instructors who have charge of the more advanced technical work of the students as to the results of instruction in English?'' the Committee received comparatively few replies. Whether the reticence of the technical men indicates a polite unwillingness to say anything disagreeable as an alternative to saying nothing at all, or whether the question was overlooked, I shall not attempt to say. Of the replies—and there were only twelve to this question out of about 107 answered questionnaires—classification may be made in equal parts, as follows: bad, might-be-worse, and hopeful; so there was not an entire lack of commendation or recognition of the work of the English instructors.

There is just one thing I want to add. One man, the dean of an engineering college, expressed the point of the whole discussion so well, I think, that his answer deserves separate consideration. The substance of his answer was that if we want good instruction in English—high class instruction, such as we attempt to get in the technical departments in which we are primarily interested—we shall have to pay for it. Hitherto English has suffered most in the make-up of the budget. The instruction in English has been turned over, not to the best man that could be obtained, but to the cheapest that the liberal arts college could furnish for this purpose. The result is that the work has been done in large part by young and incompetent instructors or fellows—or even, in one glaring instance, by a student assistant—instead of by some of the best trained men in the whole institution. In one institution the persons who teach most of the engineering English get, I understand, three hundred dollars a year for half-time work. These persons aspire, not to become better teachers of engineering English; not to analyze their problems and understand them better; but to get a disagreeable job off their hands as quickly as possible, in order that they may bask in the sunshine of pure culture in some other more congenial department.

Now, it seems to me that if an administrative officer believes strongly enough that English is a fundamental subject: if he believes that it deserves more attention than it is getting at present in most of our engineering colleges, we shall best measure the extent of his conviction, as this one dean pointed out, by the interest which he shows in allotting time and money and in giving dignity to the English side of engineering instruction.

Discussion.

Professor Wm. Kent: The report is beyond all criticism, on account of the illness of Professor Earle and the difficulties of the problem the Committee had to tackle. It is not surprising that the report is not exactly as we would like to have it, as the Committee was asked to do something that did not need to be done; that is, to report on the present status of teaching of English to engineering students. We know that is bad at the present time. The only thing we need to know is how it is being improved, and how we can measure results.

Professor Park gave me a document to read on the work that is being done at Cincinnati. That is first rate, only we want them to go a little farther and show us next year the results accomplished by that method. What we want to know is what changes have been made in the last five years or so to improve the efficiency of English teaching in our schools, and what have been the results of those changes. There may be somebody at work somewhere doing something, and recording the results.

Eight years ago I presented a paper on an experiment I conducted in Freshman English (Vol. XV, p. 90). It has been forgotten by this time and the Committee did not look it up. Possibly other experiments have been carried on since, but we do not know what the results have been. The results of that experiment showed among other improvements that the errors in spelling at the end of the year were only one third as many as they were at the beginning of the year.

I think Dr. Mann would be interested in knowing the method of teaching English in the Philadelphia Central High School fifty years ago. We had to bring in a composition every Monday morning. Eight boys were called to the blackboard and had to write a board-full from their compositions. As soon as they were done, eight more went up and put critical marks on them. Afterwards, eight more were sent up and marked over the first criticisms. Thus was developed the critical faculty. Each student would criticize another's works; and when the second lot sat down, then the professor got up and discussed the errors and showed how the sentences should be written. That was where I got the idea of students being critics.

I want to say one more thing. English is a wonderful tool for doing things with, and one of the ways of using that tool is the use of the voice. We are coming to use machinery to record the human voice. When the Freshman class comes in, they will be passed in front of a dictograph, and will say some words, and a record will be taken. Once a year they will repeat that operation, and it will be compared with previous records. At the time of graduation another record will be taken to see how they have improved in elocution, in handling their voices. If you should take dictograph records to-day of what we have heard here from different people, with their different tones of voice, we might find one record that we could take as a model. Wouldn't that be a fine thing to put before the boys? We could say then, "See, here is a voice that I heard down in Charlottesville; listen to it, and you will know how to use your voice." Wouldn't that be a good way to teach spoken English?

Professor W. T. Magruder: Professor Park has already admitted the fact that the quality of the instruction in English is extremely low, because many of the instructors are not interested in the work of teaching and only take the positions in order to enable them to earn a living while pursuing other or graduate studies. The trouble is with the administration. If the trustees can secure the funds and will put on the job instructors who are competent and trained in the art of instructing other people, and are interested in their work, the result will be much better. What we need is to dignify the whole business of instruction in English, because English is the chief mode of transferring thought from one person to another.

A friend of mine has the theory that the time is coming when we will pay our cooks at least one thousand dollars per annum, for the reason that the cook is the sole arbiter of life and happiness. At the present time, as I see it, English is the scullery maid of our engineering college household.

Professor C. Alphonso Smith: The question we have been discussing today certainly lies, it seems to me, at the very basis of English teaching, as well as successful teaching of engineering. The question which arises in my mind at the very start is, to what extent shall the teaching of English be modified to meet the varying needs of the engineer, chemist, astronomer, or business man? We are living in an age when there never were so many publications coming from the press, under the name of business English or chemical English or engineering English. It seems to be taken for granted that every highly specialized department needs a special adaptation in the teaching of English. The English language is so varied and so adaptable and so plastic that there grows up about every profession very soon a certain number of words, contractions, idioms, phrases that belong distinctively to the vocabulary of that profession. I believe that we ought to have some adaptation of English to the particular needs of the professions. But how much?

I think the danger is that we shall carry it too far. When we have made a few lists of words which students in engineering find difficulty in pronouncing or mispronouncing, when we have explained certain phrases that occur frequently in engineering usage, I believe we have gone about as far as we ought to go in adapting English to that particular need. What I think we ought to keep in mind more than anything else in the whole question of adapting English to various needs is this, that, after all the only way anybody ever does learn a thing is by drinking from the fountain instead of from the spigot. There are so many media today between us and the great sources of inspiration, which have always been sources of inspiration and always will be; there are so many media between the source and the outlet that I think we are in danger, not only of losing the thrill which comes from drinking at the source, but also of losing the idea that there is a source at all.

We are substituting grammars, rhetorics, composition books, long lists of words, these little fragments of English, for the appeal of the masterpiece itself. It is a very interesting thought to me that every time a master of English has admitted the origin of his power; when any great writer tells us where he first got his inspiration, he never points to the dictionary, or a grammar, or a rhetoric, or a list of words; but he always points to some great writer, some great masterpiece of literature—as a whole, not to a fragment. and says, "There was my teacher. I got my inspiration there."

I believe this applies to engineering. We ought, of course, always bear in mind the details of instruction—the finger exercises, we might call them—which produce mechanical accuracy in the subject; but in any institution where English is taught to engineering students, there ought to go in combination with that the possibility of the student's getting a larger inspiration from literature. I do not believe these ought ever to be separated.

It makes no difference whether you mean school or college or university. When a student begins to study in a particularized or specialized science, whenever he begins to master the English in that science, there ought to go always with these questions of mechanical excellence—punctuation, spelling, paragraphing, and the rest—the uplift of really great, stimulating literature. If he begins to drink at the source instead of at the spigot, you can give him his diploma without fear.

In other words. the common denominator between engineering and English is the thing we call constructive imagination. I believe we can take the 32,000 students of engineering in the United States and, when we teach them the mechanics of excellence, the mechanics of accuracy, give them at the same time the possibility of finding themselves in some great author, some master of English. We would thus touch their constructive imagination and increase their ability as engineers as well as their ability as masters of English.

I was interested when Lord Kelvin died in seeing that the

London *Times,* in commenting on his death, summed up his distinctive achievements in about these words. It said Lord Kelvin's distinctive power—he was the greatest maker, perhaps, of electrical instruments—lay in his constructive imagination. If you brought an electrical instrument to Lord Kelvin and said, "Can we make a better instrument than this?" he would push it aside and just surrender himself to his imagination and say, "Let me imagine a perfect instrument." When he had imagined it, he put his mechanical faculties to work in building it up. The *Times* said the excellence of Lord Kelvin consisted in the possession of that constructive imagination which "bodies forth the forms of things unknown." The writer is using there the very words that Shakespeare used to denote the great poet:

> "And as imagination bodies forth
> The forms of things unknown, the poet's pen
> Turns them to shapes, and gives to airy nothing
> A local habitation and a name."

But that constructive imagination which "bodies forth the forms of things unknown" is what you want to reach in the engineer, and what we want to reach in the teaching of English. I believe if a committee were appointed to discuss not only whether you should write candle-power with a hyphen—although I think that is valuable too—not only whether we should write horsepower as one word or two words or as a word and a half; but if a committee were appointed to select from the masterpieces of literature those which touch the constructive imagination, those that ally themselves with the great work engineers are doing, those that show that the masters of English are builders just as engineers are builders, the whole problem would be simplified. I should be greatly interested in knowing what would be selected by the teachers of engineering and of English. Gray's "Elegy" would have to be put aside. You would find that a work like "The Gold Bug" of Poe would rank as a masterpiece in reaching the constructive imagination where Lycidas and similar works would have to be shelved. Some short stories of O. Henry would, I believe, rank almost first in constructive imagination and in communicating it to the reader.

So, my friends, we might go over the list. The only appeal I make is this in our efforts to adapt English to the student of engineering, do not let us lose the larger element; do not let us forget that the great inspirations are never gained from lists of words, from little questions of whether a word is spelled this way or that; but that the power of constructive imagination which, properly developed, will make a man a better engineer, has also given the masters of literature their reach and power.

Dr. C. R. Mann: This subject of English is probably the hardest nut there is to crack in the engineering school. I was interested particularly in the remarks of the last speaker, because he began by condemning such a term as engineering English, and ended by telling us exactly what engineering English is. I think his definition of what engineering English really is, is the finest thing I have heard.

There is one problem in relation to this topic that I have been puzzling over for a long time. I want to submit it to this Society for their consideration and for assistance in its solution. It is this: We are very free with our criticisms of the department of English. The engineering students go into the department of English, and get only husks. The students all hate it. They are taught the technical trick of analyzing literary masterpieces, conducting post-mortems on poetry, and other things of that sort. We want them to get the inspiration of good literature, as has just been said. We want that, because appreciation of the human side of literature is a great asset for the engineer.

In the meantime, engineering has developed; and you can not live the ordinary life of the world today without daily contact with all sorts of engineering devices. A man can hardly be called intelligent unless he has some common sense appreciation of engineering and of what it means in life. Where in the United States can the student of literature find a course in engineering which will give him that inspirational insight into applied science which the literary man needs to complete his literature education? If any student of Shakespeare, lover of literature, comes browsing about the engineering college, what will he get but just the same sort of course in detailed technique that the engineering student gets when he invades the English department?

I am wondering if there is enough of an analogy between the two cases to raise the question whether the engineering departments do not owe something to the literary student that is quite analogous to what the literary departments owe to the engineering student. That is a problem that has puzzled me a great deal, and so I place it before you for your consideration.

Dean P. F. Walker: There is one thing in this connection which has made me want to put in just one word in connection with the topic. We have been hearing in the last day or two about the need of developing the other seventy-five per cent. of the student; and one of the points that has been mentioned in that connection is, "Have we succeeded in bringing out on the part of the student, his will, his ambition, and, we hope, some power of constructive imagination, or initiative?" I recognize very fully—and I have had many conferences with the man who has charge of the English work in the school with which I am connected—the difficulties which the teachers of English have to meet. Too often students do not see adequate reason for their being forced to go into classes in English. I believe that the responsibility for that rests very largely with the teachers of our technical subjects. At least, I believe it to be true that the situation could be modified very greatly if the teachers of the advanced technical subjects took a more vital interest in the work the English department is trying to do, and in the work which the boys are expected by the English teachers to do.

I have had occasion many times, in dealing with the work of junior and senior students, to criticize their English and insist upon a more careful consideration of the need on their part to develop better forms of expression in the writing of notebooks and reports. I believe it is a case where various departments need to break over the reserve which has been mentioned here today so many times, the reserve existing between the various departments with respect to taking up any phase of work which presumably belongs to another department. Here, I believe, beyond all others, is the place where we must go into the matter and be perfectly free to insist on a higher grade of student work. I believe that when that is done the students will go to English classes with a different spirit. I have seen it manifested in our institution.

I want to say one word with regard to our own work at the University of Kansas. We have a man who has made a special study of that work. He is an associate professor in the department of English in the University. He gives his entire time to work with the engineering students, and he is doing it well. His own work is more particularly with the advanced students, particularly the junior course in composition. He is, I believe, teaching real engineering English, although it is a composition class in the main. In that work he requires the boys to become familiar with the current technical literature of the day and with standard technical literature; and he is really developing in them, I believe, accurate methods of work and better standards of writing. We are aiming to give a still more advanced English course, more particularly to take care of those students who have shown themselves to be proficient in the work. The instructor will do that on an individualistic basis, and give them work calculated to develop form in writing, devoted in large part to the writing of articles for the public press.

My main point is this, that responsibility in very large measure rests with the teachers of the advanced technical courses.

Professor F. C. Caldwell: I am very much interested in Professor Smith's ideas. It seems unfortunate that our engineering students take so little pleasure in general reading as a form of recreation. The public schools seem generally to be unsuccessful in that which should be one of their most important functions—the creation of an interest in reading. Now if a list such as Professor Smith suggests, which would appeal to the students and which would arouse their interest in reading could be placed before them, I believe it would be a fine thing.

We now have another possibility for the effective study of English at our university, namely, the course in journalism. We are encouraging our men to elect those courses, largely from the point of view of developing their English.

Dean Fuller: We have a man here this afternoon who is not only interested in engineering English, but has exerted a very wholesome influence on the development of engineering literature. I suggest that he be drafted. I refer to Dr. Waddell.

Dr. J. A. L. Waddell: This is an old hobby of mine; and I think you are all tired of hearing me speak about it. I consider the subject of English the most important one of all for engineers who want to get to the top. It is a subject that has been sadly neglected, in nearly all the technical schools of the country, until lately, and is still being neglected in some schools. I have no patience with a faculty the members of which say: "You should not expect us to teach English here." As I have said to you, and have said to them, English is the most important thing you have to teach, and you neglect it. I think English should be taught to freshmen, sophomores, juniors, and seniors, and even in post-graduate courses. I think in every branch of engineering some writing should be done, and that all such writing should be criticized and corrected.

To get onto another hobby of mine, I think that you can improve not only English, but the entire course if you will arouse the enthusiasm of the entering freshmen. Catch them fresh and green, just as they come in, and show them what a fine thing the profession of the engineer is; how it is the most important profession of all; and what they must do to make themselves worthy members of the profession. I have been working to that end for years, and I have asked you gentlemen to help. Some have helped; others have not. I refer now to the book gotten out by Waddell and Harrington, a compilation of addresses made to engineering students, which we furnish at a very low price—below the cost of publishing. The book will soon be out of print. We printed two editions, eight thousand copies all told, and we tried to get the professors to force it upon the entering freshmen, by saying to them: ''Gentlemen, you have to read this book, for you will be quizzed on it during the course.'' Lay out a certain portion for the freshman year, and a certain part more for other years. You will do an immense amount of good to the energetic students, those who are ambitious and want to get on; because when they get a book of that kind, they will become interested in the addresses, and will read through it. I can remember when I was a student how I wanted advice such as is given in that book, and could not get it. I repeat my request, that you gentlemen give more consideration to our attempt to help the engineering profession in that way, by getting the entering freshman and the students in general to read this book.

Professor C. W. Park: I am glad we have had several angles of this discussion brought out; and I am sure that all appreciate especially Dr. Smith's presentation of the third side I referred to, you remember—English as the last stand of the humanities, as the humanizing force. Dr. Smith included English, of course, as a means of developing constructive imagination, the artistic side of engineering. That should not be overlooked. I was glad also that Dr. Smith expressed the reaction which we all feel from time to time against the highly specialized English under definite labels.

I believe that specialization in English is not justified beyond the point to which a certain definite technique may extend. I do believe that there is need for it in technical reports and in technical journalism. The lawyer has to learn how to draw up a brief; and that brief is not only the conventional language of his argument, the conventional form in which it is expressed; but it is also what the experience of generations of lawyers has proven to be the most logical way of arranging the thought and testing the validity of arguments. Similarly, an engineer is expected to write his reports and articles with definite technique. In so far as there are special forms and special kinds of technical style, they should be learned and cultivated. But I think we all agree that this should not be done to the exclusion of the big human values which Dr. Smith has so well pointed out.

It is not the policy of our Committee this year to speak definitely to the practice of particular institutions. One is always inclined, because of familiarity with his own institution, to cite illustrations of such practice; and I want to say just in a word that we have found as a result of several years' experience at the University of Cincinnati, that by giving the students instruction in what we may call the mechanics and technique of engineering expression, by keeping in touch with the students with regard to this kind of writing during the entire course, we have freed a good deal of time to be used in teaching literary English. We have gotten results that are most encouraging. The students have learned the difference between the various kinds of technical articles and they have written many articles for publication. They have also written stories; and other forms of literary composition because they wanted to do it; not because they were compelled to do it.

REPORT OF COMMITTEE ON MECHANICS AND HYDRAULICS.

Committee No. 13.

BY E. R. MAURER.

Committee Number 13 is not making any final report on any phase of its work. The main task before the Committee this past year and the year before, has been the consideration of a syllabus on the subject of dynamics. The opinions of members of the Committee were very diverse at the beginning of the work. The committee still differs more or less but their minds are gradually coming together. A small majority of the Committee might have presented a report on the syllabus at this time, but it was deemed wise to defer final presentation for another year, with the expectation that the opinion of the Committee on the final syllabus would be more nearly unanimous than it is now.

Yesterday there was distributed here a contribution from one of the members of our Committee, Professor Hoskins, in which he presents his views upon some of the perplexing things, or upon some of the things about which teachers of physics and mechanics differ a great deal. That contribution, as the title page states, is before the Committee. It was presented here informally with the expectation or hope that teachers of mechanics and physics or other members might comment on the contribution for the benefit of the Committee.

To perform a task set by the Committee on Committees, Committee Number 13 made certain inquiries by means of a questionnaire sent out some time during the winter. Only forty replies came as a result of that questionnaire, and the Committee feels that the quest for answers to the questions should be prosecuted further by means of a follow-up or possibly an additional questionnaire. So we are not presenting the results that came out of that phase of our work. But I may say in that connection that the questionnaire resulted in a pretty large collection of examination questions; something like one hundred and fifty, I think, were sent in. I have these here with me, and I will have them at the Committee table tomorrow morning. I think they may be of interest to teachers of mechanics, physics, mathematics, and perhaps others.

Discussion.

Professor J. E. Boyd: In its report, the Committee on Mathematics covered part of what I intended to say in regard to the importance of coördination in mathematics and mechanics.

In the much discussed subject of dynamics, some of the confusion which seems to exist is also due to lack of coördination in the use of the units of force and mass. The syllabus as proposed by Professor Maurer brings out clearly the two "schemes of units" and the various recognized systems of the second "scheme." The physicists, who give the first instruction in dynamics to engineering students, use the systems in which the units of mass, length, and time are arbitrarily chosen, while the unit of force is defined by means of the formula

$$\text{Force} = \text{mass} \times \text{acceleration}.$$

As they prefer the metric units they put the chief emphasis on the C.G.S. system where the dyne is the unit of force. With the pound mass and the foot, the corresponding unit of force is the poundal.

The best coördination with physics, as it is everywhere taught, may be secured by using the poundal as the unit of force and the foot-poundal as the unit of energy. One has only to remember that these are reduced to pounds force or to foot-pounds by dividing by the local value of g. Unfortunately, there are engineering books which use the system designated by "c" in the syllabus, and the student who has learned that the pound is the unit of mass, is confused to find mass given as w/g. Of course, there is no trouble if one fully understands the various systems as set forth in the syllabus, but it would be better if there were fewer systems for the beginner to learn. The absolute system as used by the physicists is thoroughly established, and teachers of mechanics should encourage its use (with the English units of course) and should discourage the introduction of new units and the use of other absolute systems.

But every system of the second "scheme" involves at least one unit of force which is not in everyday use. There are no spring balances which measure force in poundals, and there are no commercial "weights" of 32.174 pounds. The engineer, long out of college, may remember some of the formulas of dynamics but is likely to forget how and when to use g to reduce to the common units. For this reason it would be better to employ the first "scheme" where g appears in the formulas, and the units are those in common use. Some of these formulas are:

Accelerating force, in pounds $= ma/g$;

Kinetic energy, in foot-pounds $= mv^2/2g$;

Kinetic energy of rotation, in foot-pounds $= I\omega^2/2g$,

in which the mass is expressed in pounds and the acceleration and velocity in foot and second units. It is not advisable to connect g with the mass in pounds to get a new unit, or to regard it as used to reduce poundals to pounds force, but it should rather be regarded as a coefficient or as fourth term in the formula.

Several years ago Dr. Mann* called attention to the trouble in teaching elementary physics due to the little dyne. At that time I thought his ideas rank heresy. I am now sure that the absolute system should be omitted *entirely* from an elementary course. Why teach ten thousand high school pupils something they will never use for the sake of one possible investigator in physics who will have plenty of opportunities to learn the subject later? In college physics and mechanics the first "scheme" should have the preference. The absolute system should be given secondary prominence and emphasized only in those courses where it is really needed.

Professor H. S. Jacoby: Are there any suggestions for the work of this Committee during the coming year? I was very much impressed this morning by the expression of earnest desire for coöperation between physics and mathematics; and mechanics was also referred to, was it not? The matter of coördination is a mighty live one in many institutions. Do you wish to express any opinion upon it?

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* *Science*, June 18, 1909, pages 957, 958.

Dean P. F. Walker: Isn't that point covered by the motion which was passed, made by Professor Hedrick, putting the Society on record as advising committees in the different institutions, to bring about coördination?

Professor Jacoby: That applies simply to the institutions. The question I raised was in view of the strong feeling expressed in the report on mathematics, that coördination should be made a prominent feature. I want to learn your desire, whether there should be a recommendation as to active cooperation between the committees on physics and mechanics.

Professor A. M. Greene, Jr.: I think there should be coördination between physics and mechanics. I think the student gets his first ideas in the physics department, and then as he goes into applied physics: mechanics, thermodynamics, and hydraulics. It is sometimes a shock to him to learn that where W/g does equal M, W means force, and not a measure of mass. It is very important, I feel, that there should be a very close coördination between the department of physics and the department of mechanics, thermodynamics, and hydraulics.

Professor Greene: I move that it is the sense of this meeting that the Committee on Mechanics in the preparation of its syllabus hold conferences either by letter or at meetings with the Committee on the Teaching of Physics.

Motion seconded and carried.

REPORT OF THE COMMITTEE ON ECONOMICS.

Committee No. 14.

BY J. A. L. WADDELL.

The questionnaire printed below was sent to 105 deans of engineering schools in the United States and Canada. The answers have been tabulated but not completely digested, consequently the complete report will be delayed until the next annual meeting, at which time the Committee hopes to present some definite conclusions in regard to the teaching of economics in engineering schools.

Questionnaire.

A new committee on the teaching of economics has been constituted in the Society for the Promotion of Engineering Education. We feel sure that you will be interested in the purposes of this committee, and we count upon your assistance in its work. We should be very glad if you would give us your ideas on the following questions, specifically if possible, otherwise generally—in any case please give us your ideas:

1. What courses in economics are taught to your engineering students?
2. Please outline the main topics covered in each course.
3. Which of these are required and which are elective?
4. Are these all taught regularly every year; if not, what are the exceptions?
5. Are the same required (or obligatory) courses given to the students in the various divisions of engineering (civil. mechanical, electrical, etc.)? If not, what differences are made?

By the aid of your answers we hope to formulate a plan for a more complete investigation of this important subject. Obviously the result of this committee's work can be of value only in so far as it succeeds in expressing the views of those with whom it would lie to put conclusions into effect.

Have you not some suggestions as to the best way the committee should proceed in its work?

REPORT ON CIVIL ENGINEERING.

Editor's Note.—The following report contains the tabulated results of the questionnaire sent out by the Committee on Improvement in Laboratory Practice (Civil Engineering, appointed at the Princeton meeting). The data were secured in the winter and spring of 1915. The work of tabulation, etc., was done by Professors W. E. Mott and C. B. Stanton, of the Carnegie Institute of Technology.

Later this committee was combined with others to form Committee No. 15, Civil Engineering, with the same chairman but with additional members. This report, therefore, is the work of the old Committee on Improvement in Laboratory Practice and will be discussed at the Virginia meeting.

QUESTIONNAIRE.

Required
Course:—(Title) ....Catalogue No ....Optional
Taken by students in .... Eng. course..........semester of the........ year. Given during college year or summer vacation?
Number of credits given for completion of course ....
Total actual hours required for entire course. Recitation ....
Laboratory ...., Drawing room ...., Field ....
Text book used: (Please indicate under this heading what general topics are covered in the course and the approximate time apportioned to each, giving recitation, laboratory, drawing room and field work separately.)
Do you consider that more, or less, time should be given to this course than indicated above ....? Please give reasons.

SUMMER SCHOOL.

SURVEYING, GEODETIC AND RAILROAD FIELD WORK.

Where is this work carried on?
Total actual hours required:— .... Are these hours included under "Field" on the opposite page?
Are the students quartered in hotel?

Does the college own a permanent camp site? ....
Does the college operate the mess? ....If not, how are meals provided?
Is a camp ''store'' maintained? ....Is one desirable? ....
Are courses other than those indicated above given during Summer School?
What total sum is charged each student for board per week? ....
What total sum is charged each student for lodging per week? ....
What total sum is charged each student for instruction per week?......
What is the transportation expense, per student, to and from the college? ....
What other regular charges are made? ....
What equipment must the student provide?
What equipment does the college provide?
Name of College answering
....
....
(Signed).................

SHEET 1 OF 2

SURVEYING AND GEODESY

	1	2	3	4	5	6	7	8	9	10	11	12	13	4	5
No	INSTITUTION	TITLE OF COURSE	Cat No	[illegible] Course	[illegible]	Year	Term	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	TEXT BOOK	REMARKS
1	Arizona Univ of	Civil Eng	1&2	CE EM	P	So	Both	6	64	96		0	Yes	—	Elementary Topographic and Mine Surveying
	•	•	[illegible]	CE EM As	P	So	Both	4	32	56		0	Yes	—	Elementary Surveying Optional For Ass
	•	•	3	CE	O	3rd Sr	Summer	1	6	0	0	0	Yes	—	Geodesy
2	California Univ of	Surveying	[illegible]	Civil Eng and As	P	Fr	Both	6	68	34	34	0	Yes	B&H°, P&K, P & Tracy	Stadia Plane Table Hydrographic Ass get ½ time - 3 Cred
	•	Geod Surv	105	CE	P	Jr	2	2	34	0	0	0	Yes	Hosmer	Review of Least Squares Field Methods Reduction of Observa
3	Carnegie Inst of Tech	Surveying	51 52	CE ME EE EM	P	So	Both	3	34	51	0	100	No	B&H°	CLTAMS Maps and Computations, US Land Surv All S
	•	•	53	[illegible]	P	So	Summer	0	0	0	0	35	Yes	P&K	LT Computations and Maps
	•	•	56	CE EE EM	P	[illegible]	1	3	24	24		44	Yes	B&H°,	CLTAMS Maps and Computations Night Students (5 years to
	•	Geodesy	152	CE	P	Jr	2	2	34	0	0	44	Yes	B&H°2 Hosmer's Ast	∠ Base Line, Precise Leveling, Sx Latitude Time Azimuth
4	Clemson A & M College	Civil Eng	4	CE, EE	P	So	2&3	—	30	0	40	0	No	B&H°1	½ Credit System CLT
	•	•	4	CE	P	Jr	1	—	36	0	36	0	No	B&H°1	• P Sx A.
	•	•	4	CE	P	Sr	2&3	—	60	0	150	0	No	Fiebeger's Civil Eng	⅓ Surv Practice, ⅓ Railroads and ⅓ Miscellaneous
5	Colorado Univ of	Plane Surv	CE	CE	P	So	1	4	18	40	20	0	Yes	P&K	ACLTPSx US Land Topographic Mapping
	•	Top •	CE 2	CE	R	So	2	4	16	40	20	0	Yes	P&K Hosmer's Top Surv	Topographic Surveying ∠ Calculation
	•	Elem •	CE 32	ME EE Chem	P	Sr	2	2	18	36	0	0	No	P&K	Should be 3 credit hours Short Course
6	Columbia Univ	Civil Eng	25	All	P	—	—	3	45	0	0	0	No	P	CLTAPS US Land top. Given either at college or S
	•	•	155	CE EM Met Camp	R	Camp		3	0	0	0	240	—	—	LTSM
	•	•	255	CE	P	•		3	0	0	0	240	—	—	P Top surv City surv ∠ M (Advanced work on cou
	•	•	265	CE EE	P	•		2	0	0	0	96	—	—	∠ Hydrographic Gaging Current meters, Floats, Etc (Azm & Time
	•	Astronomy	175	CE	P	•		3	0	0	0	144	—	—	∠ Base Line Adjustment Quadrilateral Least Squares Time & Lat by S
	•	Civil Eng	275	EM & Met	P	•		3	0	0	0	240	—	—	Same as 255 City surv omitted Mine surv added
7	Cooper Union	Plane Surv	—	CE	O	Sr	—	0	0	0	0	30	—	Tracy	Night school students given Saturday P.M. during su
	•	Plane Surv for [illegible]	—	CE	P	3rd	Both	0	30	75	45	0	—	Tracy	A few lectures on Geodesy
9	Delaware College	Civil Eng	15	CE	P	So	Both	3	72	36	0	110	—	[illegible] & P	—
10	Denver Univ of	Surveying	5-6	Lib Arts Eng Course	O	—	Both	4	—	—	—	—	Yes	B&H°1	—
11	Florida Univ of	Surveying	1	CE	P	So	1	3	51	25	75	0	Yes	J&S	CLT US Land Plotting of maps
	•	•	2	CE	P	So	2	1½	16	20	45	0	Yes	J&S, P&K	SPSx Top, Hyd. Top Mapping
12	Franklin Union	[illegible] Surv Calc	CE	CE	P	Fr	1	—	48	—	—	—	—	Tracy & Notes	—
	•	[illegible]	CE 2	CE	P	Fr	2	—	48	—	—	—	Yes	Tracy & Notes	—
13	George Washington Univ	Surveying	CE	CE	P	So	Both	3	68	51	51	0	No	B&H 1&2	—
	•	Astronomy	8	CE	P	Jr	2	2	34	0	0	0	[illegible]	Hosmer's Ast	Azimuth & Time
14	Georgia School of Tech	Plane Surv	CE 16	CE	P	Fr	2	5½	16	48		0	—	B&H	CLTA. Comp & Draughting
	•	•	CE [illegible]	CE & ME	P	So	1 or 2	5½	16	48		0	—	Tracy	CLTS Top, Areas Comp
	•	City Surv	CE 3	CE	P	So	1	5½	16	96		0	—	B&H	SPM US Land City surv
	•	Geodesy	CE 30	CE	P	Jr	2	5½	32	48		0	—	Hosmer's Prec Surv	—
15	Georgia Univ of	Elem Surv	2	All Eng	P	So	Both	3	102	0	see note	0	Yes	B&H	CLTS Maps M Note - Average one field prob per w
16	Harvard Univ	Plane & Top Surv	ES 4b	All Course	O	Camp		—	20	70	0	160	Yes	B&H°1	CLTSP Base Line M Sx (30 hours of tests)
17	Idaho Univ of	Surveying	CE 3&4	CE EE EM	P	So	Both	8	64	192		0	Yes	J&S, P&K	EE take only one term CLTAHSM City, Mining, Top
18	Iowa State College	Civil Eng	102	CE EM	P	Fr	1	2	0	0	102	0	—	P&K	4&5 Year CE Courses and 4 Year EM Course CLT
	•	•	233	CE	P	Fr	2	2	34	0	0	0	—	J&S	4&5 Year CE Courses CLT (Theory)
	•	•	[illegible]	CE	P	Fr	2	2	17	0	51	0	—	P&K	2 Year Structural Draughtsmen & Bldg Supts Course L
	•	•	[illegible]	CE	P	So	1	2	7	0	51	0	—	P&K	2 Year Surveyors & Roadmasters Course CLT Comp
	•	•	52	CE	P	So	2	2	—	0	51	0	—	P&K	• • A and Road
	•	•	334	CE EM	P	So	1	2	34	0	0	0	—	J&S	4&5 Year CE Course and 5 Year EM M Top Mining
	•	•	335	CE	P	So	1	2	0	0	102	0	—	P&K	4&5 Year CE Course LTAP Field Methods US Land
	•	•	[illegible]	CE	P	So	2	2	0	0	102	0	—	P&K	4&5 Year CE Course LTAP Field Methods, US Land, Earthwo
	•	•	[illegible]	CE	P	So	2	3	34	0	51	0	—	J&S	4 Year CE take 457, 5 Year take both, Geod Lat Long Azm
	•	•	304	As	P	So	1	3	17	0	102	0	—	P&K	4&5 Year As Course -LTA Computations, US Land &
	•	•	[illegible]	As EM	P	So	2	3	17	0	102	0	—	P&K	5 Year EM & As • —— do ——
	•	•	45	EE ME	O	Jr	2	3	17	0	102	0	—	P&K	5 Year EE & ME Courses LTSA US Land Comput
	•	•	203	EM	P	Fr	2	3	17	0	102	0	—	P&K	4 Year EM Course —— do ——
	•	•	401	Forestry	P	So	2	2	0	0	102	0	—	P&K	4 Year Forest Course Use Forest Compass (Preparatory t
	•	•	[illegible]	•	O	So	2	2	0	0	102	0	—	P&K	5 Year Forresters Course LTSA, US Land, Computations
	•	•	[illegible]	•	P	Jr	1	4	34	0	102	0	—	P&K	5 Year • • CLTP US Land M Top Comp
	•	•	658	•	P	Jr	2	4	34	0	102	0	—	P&K	5 Year • • —— do ——
19	Johns Hopkins Univ	Surveying	—	CE EE ME	P	So	End	—	0	40	0	180	Yes	Tracy	Plane surveying only
20	Kansas State Ag Col	Surveying	I	CE	P	So	1	7	52	78		0	Yes	J&S	A Land Top H
	•	•	I	CE	P	Jr	1	7	52	38	40	0	[illegible]	J&S	City Mining Comp Curves, Top
	•	Geodesy	—	CE	P	Sr	2	4	22	12	32	0	—	J&S	∆ Base Line, Precise Levels & Map Projection
	•	Surveying	—	EE ME	P	So	2	3	11	44		0	Yes	P&K	LT Use of Instruments & A
21	Kansas Univ of	Plane Surv	CE 3	CE	P	—	—	5	68	51	54	240	—	B&H°1&2	CLTAHMS Mining, City
	•	•	CE 50	ME EE Arch	P	—	—	3	36	9	45	0	—	B&H°1	CLTAS
	•	•	CE 51	CE	P	—	—	2	0	102	0	0	—	—	Topographic & Geodetic Mapping
	•	Geodesy	CE 54	CE	O	Sr	2	3	34	0	0	0	Yes	—	Field and mapping work included under CE 2 and
22	Lehigh Univ	Land Surv	[illegible]	CE	P	So	2	4	17	26	48	175	Yes	Tracy	—
	•	Geodesy	157	CE	P	Sr	1	3	34	0	48	0	Yes	Hosmer's Prec Surv	—
23	Maine Univ of	Plane Surv	CE 1	CE Forestry	P	So	1	2½	27	0	54	0	No	J&S, P&K	CLT & US Land
	•	Plotting	CE 2	•	P	So	2	1½	0	72	0	0	Yes	•	Plotting and Computation
	•	Field Work	CE 4	•	P	So	2	1	0	0	36	0	Yes	P&K	Field work of CE-1
	•	Adv Surv	CE 22	•	P	Jr	2	2	36	0	0	0	Yes	J&S & References	∠ PS Base Line, Precise Levels
	•	Plane Surv [illegible]	CE 3&5	EE & ME	P	Jr	1	2½	36	0	36	0	No	B&H°1	Short Course (Su
24	Maryland Agriculture Col	Surveying	121	CE	P	Fr So	—	14	88	132		0	Yes*	P B&H°1, P&K	CLTSA City *Better results could be obtained in short
	•	•	121	EE	P	Fr	2	2	0	44		0	No*	P&K	Care, use and Adj of instruments and elementary operat
	•	Geodesy	121	CE	P	Jr	1	4	22	44		0	Yes	B&H°2	Azm, Lat Time ∠
	•	Surv & [illegible]	126 127	[illegible]	P	Jr So	2 1	6	22	88		0	Yes	P&K	CLTA Top Drainage, Computations Area
25	Mass Inst of Tech	Surveying	[illegible]	CE SE	P	So Jr	Both 1	—	100		300		No	B&H	Plane Top and Hyd
	•	Geodesy	[illegible]	CE	P	Jr	2	—	25	5	56		Yes	B&H°2 [illegible] Geod	∆ Base Line Long Azm, Map Proj, Calculations, Theory
26	Michigan College of Mines	Surveying	6	EM	P	Fr	2	—	12	100	380	—	—	—	Summer term
27	Michigan Univ of	Surveying	1	CE	P	Jr	1	3	24	0	24	0	No	Tracy, Allen's C&E	CLT and Surveys
	•	•	2	CE	P	Jr	2	4	32	64	64	0	Yes	—do—	SP Top Cross Sect H ∠ Maps
	•	•	4	[illegible]	P	—	Both	2	16	0	64	0	No	Tracy	LT (Given also in summer vacation)
	•	•	3&5	[illegible]	P	—	Both	8	16	192		0	Yes	Tracy	LT —— do ——
28	Mississippi Univ of	Surveying	a	CE	P	—	Both	1	5	25	30	0	Yes	P	C and Chain alone
	•	•	b	CE	P	—	Both	3	25	60	120	0	Yes	P	LTB Top
29	Missouri Univ of	Elem Surv	[illegible]	CE ME	P	Jr	1	2	18	0	42	0	No	J&S or P&K or B&H	Course to be dropped and course 102a to be substituted
	•		[illegible]	CE	P	Fr So	1	3	20	0	84	0	Yes	J&S	Arts 1 to 56, 144 to 228 CLT Azm, Trav, Comp, Map Lev
	•	Higher Surv	[illegible]	CE	P	So Jr	2	3	26	0	66	0	No	J&S ([illegible])	Arts 56 to 144 [illegible] Increase to four hour course
	•	Geodetic	[illegible]	CE	P	[illegible]	2	3	28	9	48	0	No	J&S	Chap 4 Except 452 to 462 and Chap 11, 4 lects on Merriman Chap 12&13
30	Montana State Sch of Mines	Plane Surv	—	EM	P	Fr	2	3	54	90	0	192	No	Tracy	—— (Except Arts 57-59 Chap 8 Base Line, ∠ Precise Level, Azm
	•	Mine Surv	—	EM	P	So Jr	2 1	0	36	90	0	93	—	Lectures	Surveys of Mines and Computations
31	Nebraska Univ of	Elem Surv	21	ME	P	Jr	1	2	17	0	51	0	Yes	P&K	LT Bldg, Foundations piers cross-sections, excavations
	•	Surveying	[illegible]	CE EE Arch	P	[illegible]	1 2	4	34	25	77	0	Yes	B&H, P&K	CLT Comp ,,
	•	•	CE [illegible]	CE	P	So	2	4	34	25	77	0	Yes	B&H 1&2	Part 2, Vol 2 Stadia & Mining
32	Nevada Univ of	Surveying	CE 7	[illegible]	P	Jr	Both	8	68	120	220	0	Yes	B&H 1	Ass take one term CLTASPHM Mining City Top Maps
	•	Drawing	CE 39	CE Others	O	So	2	1	0	45	0	0	No	K.S. Pamphlet	Mapping computations and conventional signs
	•	Rural Eng	CE 33	As	P	Jr	2	4	34	25	50	0	Yes	—	Land and top surv and computations

SURVEYING AND GEODESY

2	3	4	5	6	7	8	9	10	11	12	13	14	15	
TITLE OF COURSE	CAT No	STUDENTS TAKING COURSE	REQ OR OPT	YEAR	TERM	No OF CREDITS PER COURSE	TOTAL ACTUAL HRS REQ				IS TIME REQ SUFFICIENT	TEXT BOOK	REMARKS	No
							REC	DR RM	TERM FIELD	SUMMER FIELD				
ELEM SURV	Su 1	CE	R	So	1	4	45	0	30	0	Yes	J&S	C.L.T Land Surv.	33
SURVEYING *	Su 2	CE	R	So	2	4	45	0	30	0	Yes	J&S	*Title of course "Top, Hyd, City and Mine Surveying" Stream Gageing, Earthwork	
GEODESY	Su 9	CE	R	JR	1	1	15	0	0	0	Yes	Crandall's Geodesy	———	
SURVEYING	2	ALL ENGRS	R	FR	2	1	0	50		0	Yes	None	L.T Elementary problems	34
"	4	CE	R	So	2	4	32	128		—	Yes	Ive's Surv Manual, B&H	C.L.T.P. Current Meter, RR Curves, Areas	
ASTRON & GEOD	5	CE	R	JR	1	2	100			—	Yes	Hosmer's Ast & Refer	T. Sx. Altazimuth Inst, Time & Lat Obs.	
ENGINEERING	B2	ALL ENGRS	R	So	BOTH	6	34	0	51	288	Yes	J&S	CLTAMPSΔ Computations, topographic, Hydrog Base line	35
SUMMER SCHOOL	—	—	—	—	—	—	—	—	—	—	—	———	All work given at summer school (See summer school sheet)	36
PLANE SURV	1P&B2	ALL ENGRS	R	2nd	FALL ½	5	24	24	48	0	No	P&K	———	37
FIELD ENG	2P&B2	CE	R	2nd	WINTER ½	5	24	24	48	0	No	J&S	———	
GEODESY	[illegible]	CE	O	3rd	SPRING ½	2½	24	24	24	0	No	Merriman's Precise Surv	———	
SURV & LEVELING	116	CE, EE	R	FR	2	4	36	0	36	0	Yes	R	C.L.T.S. Maps, US Land Do some summer school work	38
TOP SURV	130	CE	R	So	2	3	24	18	18	0	No	Wilson and several others	Base line, S, Δ, Balancing, Ang, Azimuth.	
ELEM'TS OF SURV	201	ALL ENGRS	R	So	1	⅔	0	0	36	0	Yes	Notes	Care, use, and adj. of insts and elementary operations	39
SURVEYING	203	CE	R	So	2	3⅓	36	0	72	0	Yes	B&H	Top surv, 24 class, 48 field. Geodetic. 12 class, 24 field	
TOP DRAWING	307	CE	R	JR	1	⅔	0	36	0	0	—	None	Plotting notes from surveying course	
PLANE SURV	CE 222	CE Mun Eng & [illegible]	R	FR	2	5	32	144		0	No	B&H #1	} All of B&H #1&2 except Geodetic	40
TOP SURV	CE 223	CE Mun Eng, Irr Eng	R	So	1	5	36	54	108	0	—	B&H #1&2		
CITY SURV	CE 225	CE Mun Eng, Irr Eng	O	SR	1	3	18	54	55	0	—	B&H, J&S	Surveys etc with reference to city work	
PRECISE SURV & GEOD	CE 252	CE Mun Eng, Irr Eng	R	SR	2	3	34	0	51	0	—	Text as selected	Precise leveling Δ, Lat, Azimuth, Meridian	
TOP SURV	CE 243	Irr Eng, Farming	R	JR	1	2	0	30	18	0	Yes	———	Complete top survey and map computations	
FARM SURV & LEVEL	CE 242	AGS	R	So or JR	1	2	18	54		0	No	———	LT Drainage, Irrigation & Highway surveys	
TOP SURV	CE 233	Forestry & Logging Eng	R	So	1	4	18	36	90	0	—	B&H	Top map of forest section	
PLANE SURV	CE 232	Forestry, EM, Logging Eng	R	FR	2	4	34	0	102	0	No	B&H #1	Same as #222	
SURVEYING A	11, 12	CE, Min E,	R	JR	1	2	96		0	145	Yes	Tracy	All the book except chaps. on S P Top M Parting land earthwork. Part #3, Appendix	41
" B	13, 14	CE, Min E	R	SR	1	2	96		0	145	Yes	Tracy, B&H #2	Take all that is omited in 11.12 Selections from B&H #2	
" C	15	ME, EE	R	SR	1	½	—	48	—	0	—	Tracy or Ive's Manual	Short course may be elected by liberal arts students	
ELEM SURV	CE 1	ALL ENGS	R	FR	SPRING	3	22	0	33	0	Yes	Tracy	C L T	42
TOP "	CE 283	CE, SE	R	So	SUMMER OR FALL	4	11	33	66	0	No	Tracy	PS Top surveying	
GEODESY	CE 4	CE -	R	SR	FALL	4	36	0	36	0	No	Crandall's Geod & Notes	Precise methods	
ELEM SURV	CE 1&2	CE	R	So	BOTH	—	68	114	90	0	Yes	Tracy	L T	43
ADV "	CE 4	CE	R	JR	2	—	34	24	46	0	No	B&H #2	———	
CIVIL ENG	5	CE	R	So	2	—	54		0	198	No	J&S, Nagle	Given during summer vacation, A, Δ, Hyd, Base line, M, RR surv	44
SURVEYING	IX-1-7	CE	R	FR	1	—	120	36	0	0	TOO MUCH	B&H #1	Whole volume	45
"	IX-2	CE	R	FR	SUMMER	0	0	0	0	95	—	———	———	
"	IX 3	ME	R	JR	"	0	0	0	0	72	—	———	———	
ELEM SURV	—	CE	R	FR	2	3	27	54	108	0	Yes	R	One added credit may be elected More time desired if it could be put in the (summer CL-A Camp survey)	
TOP SURV	—	CE	R	So	1	3	0	54	108	0	Yes	R	T.S.P.Δ Map	
SURVEYING	302	CE	R	So	2	—	50	0	20	100	Yes	———	CLT and problems, planimeter, mining	47
PLANE SURV	303	EE	R	So	2	—	33	0	0	100	Yes	Barlow, Plane Surv	CLTAS	
ASTRON & GEOG	319	CE	R	SR	2	—	72	36	36	0	Yes	B&H #2	May cut to 3 hours recitation. Δ, M, Precise leveling, P, Map projection	
PLANE SURV	CE 118-2	CE EM MET FORESTERS	R	JR	1	—	45	60	0	130	Yes	SHERMAN'S LETTERING Tracy, Surv & Field Man'l	C.L.T Map and computations	48
ELEM SURV	CE 1&2	ALL ENGRS	R	FR	BOTH	8	64	32	160	0	No	B&H #1, P&K	CLTASP Top, simple curves	49
HIGHER SURV	CE 3	CE	R	So	2	4	32	32	64	0	No	B&H #2	Top Mapping	
SURVEYING	CE 5a&6a	CE	R	So	BOTH	—	160	0	192	288	—	J&S	All the book except chaps 10 and 11, includes lectures in RR surveys (Top Draw 3hrs (per week 1ST Term JR)	50
PLANE & MINING SURV	CE 5&6	MET & EM	R	So	"	—	96	0	96	144	No	J&S, Durham Mine Surv	First 8 chaps. & 11, 12 & 13 Eight weeks Durham. 1 week mine survey	
PLANE SURV	CE 5&6a	EE	R	So	1½	—	72	0	96	96	YES	J&S	First 8 chaps. 12&13	
SURVEYING	1a	ALL ENGRS	R	FR	BOTH	2½	0	0	135	0	YES	R	US Land, use of insts. etc. To be given in summer school next year	51
SURVEYING	4	CE	R	So	2	3	0	0	162	0	YES	R	Top, Hyd, Mining, Volumes, Maps	
FIELD ASTRON.	6	CE	R	JR	1	1	—	27	—	0	Yes	———	Azim, Lat, Long, Time. Methods adapted to field instruments	
SURVEYING	—	ME	R	FR	END	—	8	32	56	0	No	Notes	L.T.S.	52
SURVEYING	223	CE, EE, ME	R	So	2	2	16	9	39	0	No	B&H	C.L.TA Methods, computations, plotting	53
SURVEYING	224	CE	R	JR	1	2	0	36	60	0	No	B&H #1	Top Mapping, S, Buildings, sewers, pavements, precise chaining	
———	453 45&48	CE	R	So	BOTH	3	51	102	102	0	Yes	J&S	———	54
SURVEYING	IXb	EM	R	FR	2	3	50	0	0	280	Yes	Tracy	US Land, mineral surv Use of insts	55
CIVIL ENG & DRAW	1a	SCIENCE	O	—	1	—	17	68		0	Yes	———	Use of insts.	56
PLANE SURV	SL21	CE	R	So	1	2	6	0	44	0	Yes	B&H #1&2, J&S, P&K	C.L.T	57
HIGHER SURV & AST	SL26	CE	R	So	2	3	8	12	56	0	Yes	—do—	S.P.M.Δ Base line	
TOP DRAWING	SL31	CE	R	JR	1	3	4	72	0	0	—	B&H, J&S	Plotting maps and computations	
ELEM SURV	SL 23&24	ME, EE CHEM, ARG	R	So	2 1	2	6	0	44	0	Yes	P&K	Short course	
ELEM SURV	Surv 1	CE, EE, ME, EM, CHEM	R	So	BOTH	4	34	34	68	0	No	J&S, P&K	CLTP Underground surv Sx.	58
MINING SURV	Surv 2	CE EM.	R	JR	SUMMER	6	0	100	200	0	Yes	———	Underground 180, claims 120	
PLANE SURV	—	CE, ARCT	—	FR	3	1	60	0	120	0	Yes	R	CLTA Sx, Comp and U.S. Land	59
TOP SURV	—	CE	—	FR	4	1	12	20	148	0	Yes	R	Trav. Top, P.S., 3 point prob, Map etc,	
SURVEYING	1	CE, EE, ME	R	So	1	4	32	30	66	0	Yes	Yeoman & Tuckers Field M R	More time needed for ME	60
"	1	CE	R	So	2	4	32	30	66	0	Yes	—do—	Opt for ME, EE, & Chem, R 236 to 471, Top, Hyd, L.T.S.P.Δ	
GEODETIC SURV.	3	ALL	O	SR	1	3	48	—	—	—	Yes	Gore's Elem of Geod.	Not elected for past five years	
PLANE SURV	20	ALL	R	FR	2	4	32	36	60	0	No	Tracy	LTA computations	61
TOP SURV	23	CE	R	JR	1	3	16	0	32	0	No	J&S	Δ Base line PS Photographic surv, Map	
SURVEYING	II	ALL ENGRS	R	FR	1, 2 & 3	4	100	33	33	0	Yes	Merriman & Brooks Surv Allens RR, K.S. Pamphlet on Mapping	2 Hours per week of surveying practice the following year Six weeks of summer school (should be given)	62
LAND SURV.	100	CE. EM	R	FR	2	3	60	60	60	0	No	Gillespie & B&H	A.M Surv., computations, retracing old surveys	63
"	101	EE ME	R	FR	2	1	20	20	20	0	—	———	C.L.T Areas	
"	102	CE EM.	R	So	1	2	40	40	40	0	—	B&H	A.S. etc	
"	103	CE EM	R	So	2	2	20	60	80	0	—	J&S, & Tracy	Top, Hyd, Barometer, Mapping	
ELEM. SURV.	TE 1	CE	R	FR	1	2	8	8	60	0	—	J&S	L. Computations. Also offered in summer school	64
"	TE 2	CE	R	FR	2	2	8	0	60	0	Yes	J&S	C.L.T.A.	
"	TE 3	CE	R	So	1	3	34	48	24	0	—	J&S	TPΔ Sx, Lat, Azimuth, Mapping, Pen Top. Planimeter	
"	TE 4	CE	R	So	2	4	30	40	60	0	No	J&S	Mine, Hyd, City, Mapping	
GEODESY	TE 5	CE	O	JR	2	3	32	0	16	0	Yes	J&S	Δ Precise Level, Map Projections, Lat, Azim, Long, Time	
ELEM. SURV.	—	—	—	—	—	3	54	0	108	0	—	B&H #1	C L T S Map, Meridian	65
LAND SURV.	CE 1	CE	R	So	1	—	16	64	80	0	—	J&S Ive's & Hill's Man'l	———	66
SURVEYING	CE 2	ME, EE	R	So	1	—	0	64		0	—	Ive's & Hill's Surv Man'l	Elective for Sr. Chemists	
SURVEYING	CE I	CE, EM, EE, ME, Irr E, Ag	R	FR	1	2	—	—	—	—	No	J&S	C.L.T.A.	67
"	CE II	CE, EM, Irr E	R	FR	2	2	—	—	—	—	No	J&S	P.S. Continuation of CE I	
"	CE III	CE & Irr E.	R	So	1	3	—	—	—	—	No	R Field Geom.	Top, Hyd, Railroad Survey	
"	CE IV	CE & Irr E	R	So	2	3	—	—	—	—	No	J&S, & References	Mining & city surv. Elem geodesy and map projections [Mining students take part on mining)	
SURVEYING	CE 14	CE, ME, EE	R	FR	BOTH	2	18	0	32	0	—	Barton's Plane Surv.	C.L.T.A Computations. Rec 1 hr. periods varying with weather, Field 2 hr.	
"	CE 16	CE	R	JR	BOTH	7	72	30	75	0	—	———	P.S. Circ. curves, earthwork, top, Sx, Field Ast, RR Spur, map with conventional signs	
ELEM. SURV.	CE 4a	CE, EM	R	So	1	5	30	45	95	0	—	No special text	———	
"	CE 4b	ME, EE	R	JR	1	2	—	—	—	—	—	———	———	
PLANE SURV.	27	CE, ME, RyCE, MSE	R	So	1	3	27	9	18	0	No	B&H #1, Davis-Field Man'l	Land surveying, areas, plotting	68
HIGHER "	28	RyCE, CE, MSE	R	So	1	3	27	9	18	0	"	B&H #1&2, Davis-Field Man'l	Top. surv, astronomical observations	
PLANE "	31	LANDSCAPE	R	So	1	3	27	9	18	0	YES	Raymond	———	
TOP "	32	"	R	So	1	3	27	9	18	0	"	"	———	
ELEM "	76	C&E Engr ALL ENGRS	R O	JR	1	2	24	2	10	0	"	Davis-Field Manual	Elementary problems, computing	

used no reply was made. Hours given do not include preparation.

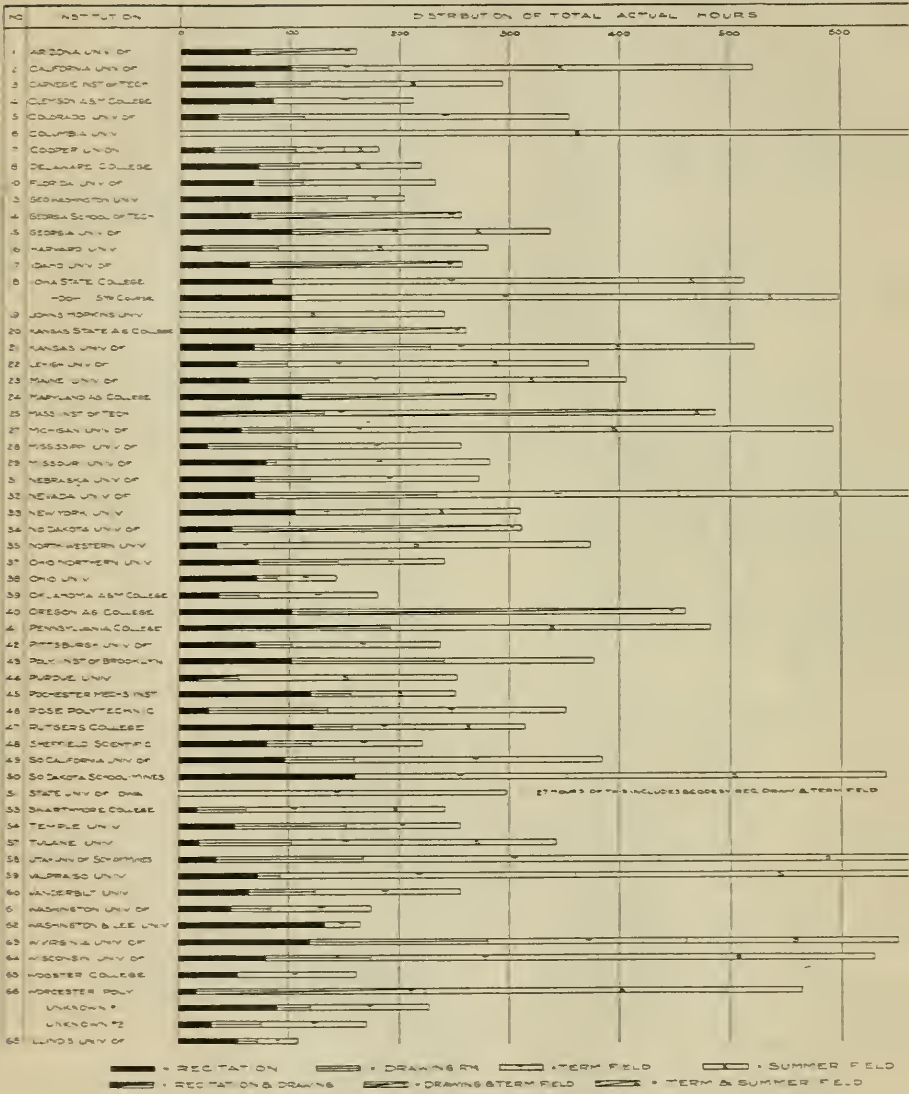
rveying included exercises in pacing, chaining and ranging.

eviations:- B&H = Breed & Hosmer, J&S = Johnson & Smith, R = Raymond, P&K = Pence & Ketchum.

ering work done in following branches:- C = compass, L = levels, T = transit, A = adjustments, S = stadia, P = plane table,

triangulation, M = meridian observations.

SURVEYING AND GEODESY

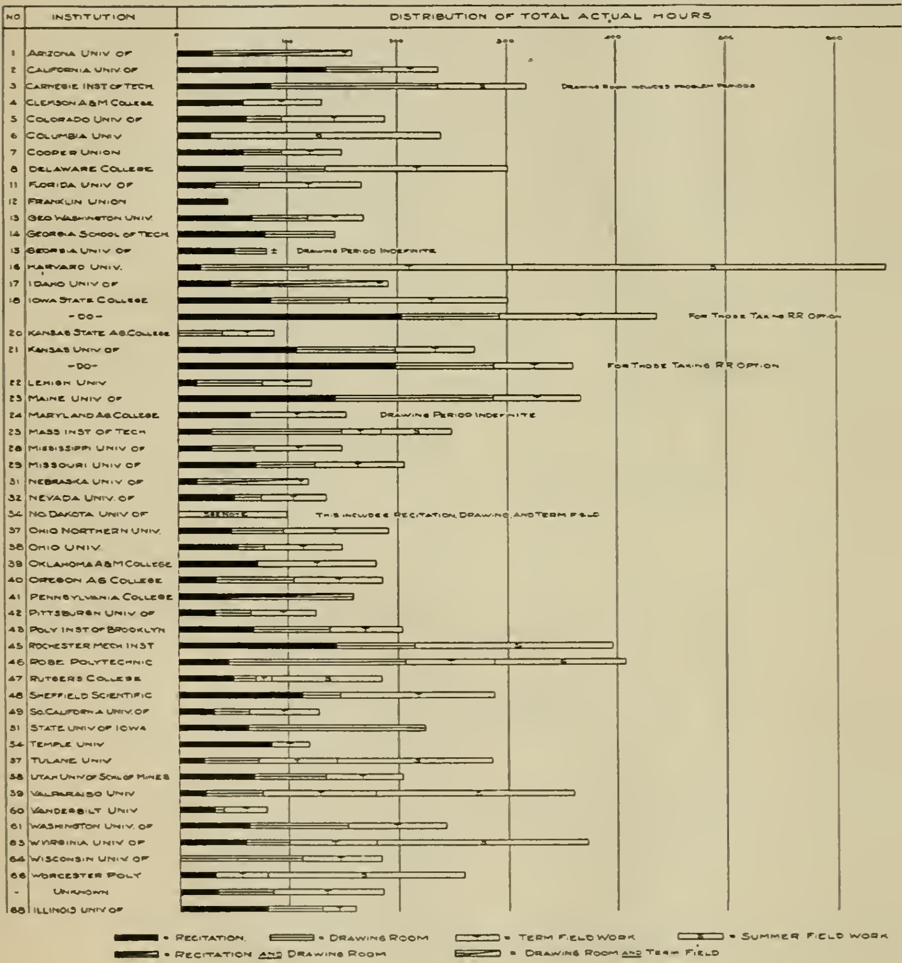


RAILROADS

2	3	4	5	6	7	8	9	10	11	12	13	14	15	
TITLE OF COURSE	CAT NO	STUDENTS TAKING COURSE	REQ OR OPT	YEAR	TERM	No OF CREDITS FOR COURSE	TOTAL ACTUAL HRS REQ				IS TIME REQ SUFFICIENT	TEXT BOOK	REMARKS	No
							REC	DR RM	TERM FIELD	SUMMER FIELD				
RR Surv	CE 9.10	CE	R	Jr	Both	4	32	128		0	—	—	—	1
RR Surv.	CE 102ab	CE	R	Jr	1	3	34	0	51	0	Yes	Allen, Curves & Earth.	Curves, Spirals, Earthwork & Turnouts	2
"	CE 102c	CE	R	Jr	2	1	0	51	0	0	—	—	Plotting surveys above [Latimer, Sig Dict, Adams, Scott, Camp & Troutman]	
RR Eng	CE 104ab	CE	—	Sr	Both	6	102	0	0	0	Yes	See Remarks	RR Option, economics, construction, signalling, interlocking Ref books, Wellington, Webb, Raymond, Crandall & Barnes	
RR Eng.	156 157	CE	R	Jr	Both	4	34	102	0	80	Yes	Allen Curves & Earth	Curves, Earthwork, Spirals, Turnouts, Crossings, Drawing room, Computations	3
"	160 161	CE	R	Sr	Both	4	51	51	0	0	Yes	Raymond, RR Eng	RR Economics, maintenance, signals, interlockings, etc	
"	159	EE, SE, EM	R	So Jr	2 EE 2 SE, EM	2	20	48	0	0	Yes	Allen, Curves & Earth	Simple curves, spirals, vertical curves & earthwork, Drawing room, computations	
"	156	CE Night	R	3rd	Both	3	24	24	0	45	Yes	"	One half of course 156 & 157	
"	160	CE	R	5th	Both	4	24	48	0	0	Yes	Raymond, RR Eng	" 160 & 161	
Civil Eng	—	CE	R	Jr	2 & 3	—	60	0	72	0	No	Webb, RR Const	Curves, location & earthwork	4
RR Curves	R, CE 1	CE	R	So	2	1	15	0	30	0	Yes	Allen, Curves & Earth	Curves	5
RR Eng	R, CE 2	CE	R	Jr	1	5	48	32	64	0	Yes	Allen, Webb, Talbot (Spiral)	RR Option, take 8 credits additional on location, economics, maintenance, map, etc.	
Civil Eng	715	CE	R	—	—	2	0	0	0	96	—	—	RR recon, prelim location 2 to 5 Mi line, yard & maintenance work	6
"	285	EM, Met	R	—	—	2	30	0	0	114	—	—	" " " " " " "	
RR Eng	—	CE	R	Sr	1 & 2	—	60	35	55	0	—	Allen, Curves & Earth	All of Allen & lectures on maintenance	7
RR Surv, Cons, & Economics	60	CE	R	Jr	Both	8	60	75	166	0	Yes	See Remarks	Curves, earthwork, location, economics, Webb, RR Eco, Crandall & Barnes & Crandall Earthwork	8
Railroads	I	CE	R	So	2	1½	34	0	34	0	—	Allen, Curves & Earth	Curves, spirals, earthwork, crossings, wyes, field work	11
"	II	CE	R	Jr	1	1½	0	25	75	0	—	Notes	Prelim location of 1 Mi line, maps, earthwork	
RR Cons & Earth	CE 3	CE	R	Jr	Both	—	46	0	0	0	Yes	Tracy & Notes	—	12
RR Eng	2	CE	R	Jr	Both	3	68	51	51	0	No	Allen, Beahan	Curves, spirals, earthwork, prelim location, map of RR, computations & mass diagram	13
Road & RR Surv	CE 4	CE	R	—	—	—	16	64		0	—	Allen, Searle	—	14
Road Econom	CE 11	—	—	—	—	—	64	—	—	—	—	Raymond, RR Eng	—	
RR Eng	82	CE, EE	—	—	Both	3	51	30±	60	0	No	Allen, Baker, R&P Strahan	RR Economics, spirals, switches	15
RR Surv	ES4d	—	O	—	—	1	20	100	185	0	Yes	Allen, Curves & Earth	Preliminary location, earthwork, mass diagram	16
RR Eng	CE 25 26	CE	R	Jr	Both	6	48	144		0	Yes	Webb, RR Const	Curves, Earthwork, location	17
RR Location	CE 510	CE	R	Jr	1	5	51	18	90	0	Yes	Allen's Curves - Notes	Location, curves and earthwork	18
RR Cons & Maint	CE 611	CE	R	Jr	2	4	34	54	54	0	Yes	Crandall & Barnes, Talbot, Notes	Survey of existing railroads, yards and interlockings	
RR Eng	CE 760	CE	—	Sr	1	2	34	0	0	0	Yes	Notes	Electric railways compared to steam use in towns and tunnels	
RR Signalling	CE 754	CE, EE	—	Sr	1	1	17	0	0	0	No	Latimer	Interlocking and signalling	
RR Design	CE 862	CE	—	Sr	2	3	34	17	0	0	Yes	ARE Proceedings	Design of yards and terminals, cooling and watering plants and treatment of water	
RR Operation	CE 863	CE, EE	—	Sr	2	2	34	0	0	0	Yes	Notes	RR Operation	
RR Eng	II	CE	R	Sr	2	4	0	40	48	0	Yes	No Text	RR Surv based on Raymond & Nagle	20
RR Surv	CE 55-56	CE	R	Jr	1	7	54	90	72	0	Yes	Allen & Talbot	—	21
RR Econ Location	—	CE	R	—	—	3	54	0	0	0	—	—	—	
RR Terminals	—	CE	O	—	—	2	36	0	0	0	—	—	Required of all students taking railroad option	
RR Maint & Oper	—	CE	O	—	—	3	54	0	0	0	—	—	" " " " " "	
RR Surv	165	CE	R	Jr	2	4	17	60	45	0	—	Allens C&E	Expect to put field work in summer school	22
RR Curves	CE 6&8	CE	R	So	2	3	32	0	32	0	—	do	Curves and earthwork	23
RR Const	CE 25	CE	—	Jr	1	2	32	0	0	0	—	Allens, Wilson's	—	
RR Field & Office	CE 21-23	CE Forst	R	Jr	1	2	0	48	48	0	—	Allen's, C&E	Preliminary location and mapping	
RR Eng	CE 63	CE	—	Sr	1	3	48	0	0	0	—	Raymond, RR Eng, Webb	RR Economics	
RR Eng	CE 64 66	CE	—	Sr	2	5	32	96	0	0	—	Raymond, RR Eng - Orrock	RR Structures, Maps, locations from US Geol Survey turnouts and yard design	
RR Eng & Prin Prac	123 127	CE	R	Jr	Winter & Spring	10	66	Indef	88	0	No	Allen's C&E	Curves, location and earthwork	24
RR Field Work	120	CE, SE	R	So	Summer Location	—	30	120	35	65	Yes	— do —	—	25
Surveying	—	CE	R	—	Both	3	30	40	80	0	No	Raymond, RR Eng & Searle	Surveys for railroad and highway computation and estimates	28
RR Surv	111a	CE	R	—	1	5	39	36	51	0	Yes	Webb, Talbot	Curves and earthwork, turnouts and crossing	29
RR Eng	112b	CE	O	—	2	3	32	18	30	0	Yes	Webb	Earthwork, haul, tunneling and economics	
RR & Hwy Surv	CE8	CE	O	Jr	1	3	17	102		0	Yes	Raymond, Field Geom.	Preliminary location, survey of railroad	31
RR Eng	26	CE	R	Sr	1	5	51	25	60	0	No	Pickels & Wiley	Curves, earthwork, location, railroad economics	32
RR Eng	9 & 10	CE	R	Sr	Both	4		100		0	Yes	Several, None Required	Economics, location, curves, earthwork, materials and maintenance of way	34
RR Surv	3	CE	R	So	Spring &	5	24	24	48	0	Yes	Searle	—	37
RR Econom	4	CE	R	—	Summer &	5	24	24	48	0	Yes	Wellington	—	
RR Eng	119	CE	R	So	1	4	54	24	72	0	Yes	Searle	Preliminary location, earthwork, curves & tunnels	38
RR Surveying	204	CE	R	So	2	4	36	0	108	0	—	Allen	Curves location, earthwork	39
RR Eng	405	CE	R	Sr	1	2	36	0	0	0	—	Raymonds RR Eng	—	
RR & Canal Surv	CE 272	CE Hwy Irr	R	So	2	5	34	72	81	0	—	Allen	Curves earthwork, location.	40
RR Surv	CE 274	Logging	R	So	2	4	34	42	60	0	No	do	" " " less field work than 272	
Railroads A	16	CE & Min	R	Jr	2	2	64	0	0	0	—	Allen	—	41
" B	17	CE	R	Sr	2	1	96		0	0	—	—	Field work given in "Surv B" [staking out work]	
RR Loc & Cons	CE5	CE	R	So	Summer	4	22	0	60	0	No	Allen	4 Terms per year Summer Camp in future Curves, spirals, turnouts, crossings, comp	42
"	CE6	CE	R	Jr	Fall or Winter	2	11	33	0	0	No	Crandall & Barnes	— do — — do —	
RR Curves & Earth	CE 9-10	CE	R	Jr	1	—	68	70	66	0	Yes	Allen & Lectures	Everything in railroads	43
RR Eng.	IX-9	CE	—	Jr	Both	—	144	72	0	0	Too much	Allen	Entire book	45
"	IX-10	CE	—	Jr	Summer	—	—	—	—	—	—	—	—	
RR Surv	—	CE	R	So	2	3	27	0	81	0	Yes	Nagle	Curves, spirals, earthwork, turnouts	46
Practice in CE	—	CE	R	Jr	1	4	18	162	0	0	Yes	Raymonds RR Eng	Map, design of structures, costs	
RR Eng.	308	CE	R	Jr	2	—	50	20	15	100	Yes	Carhart's [Curves & Earth]	Recon, prelim location, curves and earthwork, spirals, turnouts, etc	47
RR Curves & Earth	—	CE	R	Jr	2	—	60	0	0	30	Yes	—	—	48
RR & Top Surv	CE 13	CE	R	Sr	1	—	0	0	0	145	Yes	Allen, Sherman, Tracy & Tracys Exercises	Vacation work, curves, etc.	
RR Mapping	CE 23	CE	R	Sr	1	—	0	60	0	0	Yes	"	Mapping, computations & earthwork	
RR Eng	CE 483	CE	—	Jr	Both	5	32	32	64	0	No	Allen	Prelim location, curves, earthwork, estimates & costs	49
RR Surv	5	CE	R	Jr	2	3	0	162	0	0	No	Raymond, Field Geom	Curves & Earthwork	51
RR Eng	13	CE	R	Sr	1	3½	63	0	0	0	Yes	Raymonds RR Eng	Economics & Maintenance	
RR Curves	416 417	CE	R	So	Both	1½	51	0	0	0	Yes	Allen	—	54
Railroads	415	CE	R	So	2	1	34	0	34	0	Yes	Tratman	—	
RR Eng	16	Science	O	—	2	—	17	68		0	Yes	—	RR location theory, volumes, maps, field work	56
RR Surv	RRL 32	CE	R	Jr	2	3	12	0	60	0	Yes	Allen, Searle, Lavis	Curves, Reconnaisance, preliminary & Location	57
RR Map & Earth	RRL 41	CE	R	Sr	1	3	10	50	14	0	—	— do —	Map earthwork, turnout, computations, wyes, crossings	
RR Surv	Surv 4	CE, EE	—	Jr	Both	6	68	66	70	0	Yes	Webb & Tratman	Curves, earthwork, turnouts, maintenance, construction and yard survey	58
RR Cons & Loc	—	CE	—	So	1	1	24	52	104	0	Yes	Raymond, RR Eng, Nagle	Location, surveys, estimates, etc.	59
Field Eng of RR	2	CE	R	Jr	2	3	32	8	40	0	Yes	Allen, Lavis	Curves, spiral, earthwork, 2 Mi. location optional for ME & EE	60
Const Surveying	22	CE	R	So	1	3	16	16	48	0	No	Allen	Curves, earthwork, location	61
RR Operation	31	CE	—	Jr	1	3	32	26	26	0	Yes	Allen, Searle, Talbot Raymond, RR Eng - Crandall	½ Spirals and turnouts and ½ RR Operation	
RR Location	32	CE	—	Jr	2	2	16	48	16	0	No	Raymond, RR Eng, Crandall	Paper location, continuation course *31	
RR Location	104	CE	R	Jr	1	3	60	40	80	0	—	Searle		63
RR Curves	1	CE	R	So	1	45	0	64	24	0	—	Allen, Talbot	Curves and spirals	64
RR Loc & Cons	26	CE	R	Jr	1	3	0	48	48	0	Yes	Allen, Lavis	Preliminary location, maps, etc	
RR Design	106	CE	O	Jr or Sr	2	2	—	—	—	—	Yes	—	Frog & switch design, resurvey of yards, maintenance survey	
RR Eng	104	EM, EE	O	Jr or Sr	1	2	16	24	24	0	No	Allen	Curves, earthwork & location	
RR Curves	CE 4	CE	R	So	2	—	32	0	48	180	—	Allen	—	66
RR Surv	CE 6a	CE	R	So	2	5	34	51	102	0	Yes	—	—	
RR Location	CE 6b	CE	O	Jr	1	2	—	—	—	—	Yes	—	—	
RR Cons	CE 6c	CE	O	Jr	2	1 or more	—	—	—	—	—	—	—	
RR Surv	CE 51	CE	R	Jr	1	5	80	50	30	0		Pickels & Wiley	Curves, location, earthwork, turnouts, switches, crossings, etc	68

no reply was made

RAILROADS


NO
INSTITUTION
DISTRIBUTION OF TOTAL ACTUAL HOURS
0
100
200
300
400
500
600
1 Arizona Univ of
2 California Univ of
3 Carnegie Inst of Tech.
4 Clemson A&M College
5 Colorado Univ of
6 Columbia Univ
7 Cooper Union
8 Delaware College
11 Florida Univ of
12 Franklin Union
13 Geo Washington Univ.
14 Georgia School of Tech
15 Georgia Univ of
16 Harvard Univ.
17 Idaho Univ of
18 Iowa State College
-DO-
20 Kansas State Ag College
21 Kansas Univ of
-DO-
22 Lehigh Univ
23 Maine Univ of
24 Maryland Ag College
25 Mass Inst of Tech
28 Mississippi Univ of
29 Missouri Univ of
31 Nebraska Univ of
32 Nevada Univ. of
34 No Dakota Univ of
37 Ohio Northern Univ.
38 Ohio Univ
39 Oklahoma A&M College
40 Oregon Ag College
41 Pennsylvania College
42 Pittsburgh Univ of
43 Poly Inst of Brooklyn
45 Rochester Mech Inst
46 Rose Polytechnic
47 Rutgers College
48 Sheffield Scientific
49 So California Univ of
51 State Univ of Iowa
54 Temple Univ
57 Tulane Univ
58 Utah Univ of Sch of Mines
59 Valparaiso Univ
60 Vanderbilt Univ
61 Washington Univ of
63 Virginia Univ of
64 Wisconsin Univ of
66 Worcester Poly
- Unknown
68 Illinois Univ of
Drawing Room includes problem periods
± Drawing Period Indefinite
For Those Taking RR Option
For Those Taking RR Option
Drawing Period Indefinite
This includes Recitation, Drawing and Term Field
= Recitation
= Drawing Room
= Term Field Work
= Summer Field Work
= Recitation and Drawing Room
= Drawing Room and Term Field

SUMMER SCHOOL FIELD PRACTICE
SURVEYING, GEODESY AND RAILROADS

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
STUDENTS ATTENDING AND YEAR	ATTENDANCE HOURS REQUIRED PER YEAR	PLACE WHERE THE INSTRUCTION IS GIVEN	IS CAMP MAINTAINED BY INSTITUTION	LIVING QUARTERS	MESS IS OPERATED BY	IS A STORE		CAMP EQUIPMENT FURNISHED BY		EXPENSES PER WEEK				TRANSPORTATION ONE WAY	OTHER COURSES GIVEN	No.
						[illegible]	[illegible]	STUDENTS	SCHOOL	BOARD	LODGING	MATTRESS	OTHER			
ONE YEAR	350 to 360	SWANTON, CAL.	YES	TENTS	SCHOOL	YES	YES	LINEN, TOWELS, ETC	BLANKETS, CAMP OUTFIT	—	$\$5^{00}$	—	0	$\$2^{25}$	NO	2
C.E. S.E. & E.M. SOPH SURV	130	CARVERS FERRY, PA	•	TENTS	SCHOOL	NO	NO	LINEN, TOWELS, ETC	BLANKETS, CAMP OUTFIT	$\$5^{50}$	0	0	0	.70	NO	3
SURV ALL OTHERS	85	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
RR JR CE	80	•	•	•	•	•	•	•	•						•	
GEOD JR C.E.	50	•	•	•	•	•	•	•	•						•	
SURV CE NIGHT	45	•	•	•	•	•	•	•	•						•	
RR CE NIGHT	45	•	•	•	•	•	•	•	•						•	
ALL COURSES ANY YR	AS MANY AS REQ	BANTAM, CONN	NO	BARRACKS	CONTRACT	YES	YES	BLANKETS, LINEN, TOWELS, ETC	COT, MATTRESSES, ETC.	$\$6^{75}$	—	YES	NO	$\$6^{00}$	YES	6
C.E. 5TH YR NIGHT	30	IN CITY PARKS	NO	—	—	—	—	—	—	—	—	—	—	—	—	7
—	110	ON CAMPUS	NO	BOARD HO	BOARDING HO	NO	—	—	—	—	—	—	—	—	YES	9
CE STUD	36	ON VACANT PROP	—	—	—	—	—	—	—	—	—	—	—	—	—	12
NOTE:- Entire Student Body Hired Out For One Week Each Year Students Must Take Three Years																15
SURVEY OPT	280	SQUAM LAKE, NH	YES	TENTS	SCHOOL	YES	YES	BLANKETS, LINEN, TOWELS, ETC	CAMP OUTFIT	$\$6^{00}$		$\$2^{00}$	0	$\$7^{00}$	NO	16
R.R. OPT	340	•	•	•	•	•	•	•	•	•					-	
CIV SUBST ENG WK C.E. ALL 3 YRS	96	SPIRIT LAKE, IA	NO	HOTEL	HOTEL	—	—	—	—	$\$7^{00}$		0	0	$\$3^{00}$	NO	18
C.E. M.E. E.E. SOPH SURV	220	CAMPUS	YES	—	—	—	—	—	—	—	—	—	—	—	YES	19
SOPH	240	5 MI FROM CAMPUS	NO	TENTS	SCHOOL	NO	NO	BLANKETS, LINEN, TOWELS, ETC	CAMP OUTFIT	$\$5^{00}$	—	—	—	—	—	21
SOPH	178	SAYLORSBURG, PA	NO	HOTEL	HOTEL	NO	NO	—	—	$\$10^{00}$		NO	NO	$\$2^{00}$	NO	22
JR	108	ON CAMPUS	NO	BOARD HO	BOARD HO	COLLEGE STORE		—	—	—	—	—	$\$2^{50}$	—	NO	23
BET 2ND & 3RD YRS	SURV 300	EAST MACHIAS, ME	YES	TENTS	SCHOOL	YES	YES	LINEN, TOWELS, ETC	BLANKETS, CAMP OUTFIT	$\$7^{00}$		NO	DEP CAMP	$\$15$	YES	25
•	GEOD 56	•	•	•	•	•	•	•	•	•		•	•	•	•	
•	RR 65	•	•	•	•	•	•	•	•	•		•	•	•	•	
MINING STUDENTS	600	NEAR CAMPUS	NO	BOARD HO	BOARD HO	NO	NO	—	—	—	—	—	—	—	YES	26
C.E. 3RD YEAR	384	DOUGLAS LAKE, MICH	YES	TENTS	SCHOOL	YES	YES	NOTHING	BLANKETS, CAMP OUTFIT	$\$3^{70}$	$\$1^{25}$	$\$2^{50}$	0	$\$8^{00}$	NO	27
SURV FR	192	CHANGES	NO	TENTS	RANCH HO	NO	NO	NOTHING	BLANKETS, CAMP OUTFIT	$\$7^{00}$	0	0	0	$\$2^{70}$	NO	30
—	280	MINING CAMPS	NO	TENTS	MINING CAMP	NO	NO	BLANKETS, LINEN, TOWELS, ETC	CAMP OUTFIT	$\$7^{00}$	0	0	0	[illegible]	YES	32
SURV SOPH	144	WEBSTER LAKE, MASS	NO	BOARD HO	BOARD HO	NO	NO	—	—	$\$8^{00}$		$\$5^{00}$	0	$\$4^{00}$	NO	33
R.R. JR	144	•	•	•	•	•	•	—	—	•		•	0	•	•	
ALL SOPH	288	LAKE CO, ILL.	•	TENTS	SCHOOL	NO	NO	BLANKETS, LINEN, TOWELS, ETC	CAMP OUTFIT	$\$6^{00}$	0	$\$1^{00}$	0	$\$1^{50}$	NO	35
LAND SURV FR	190	NEAR COLLEGE	—	—	BOARD HO	NO	NO	—	—	$\$4^{00}$	$\$4^{00}$		—	—	NO	36
SURV CE & EE JR	180	•	—	—	•	•	•	—	—	•	$\$5^{00}$		—	—	•	
R.R. JR	90	•	—	—	•	•	•	—	—	—	$\$4^{00}$		—	—	—	
NOTE:- Experience Gained in Practical Work																40
SURV CE & MIN JR	290	ON CAMPUS	NO	—	—	—	—	—	—	—	—	—	—	—	NO	41
SURV CE SO	198	PENTWATER, MICH	NO	HOTEL	—	NO	NO	BLANKETS, LINEN, TOWELS, ETC	—	$\$3^{20}$	$\$0^{80}$	0	0	$\$15$	NO	44
SURV C.E. FR	95	SUBURBS	NO	BOARD HO	BOARD HO	NO	NO	NOTHING	NOTHING	—	—	$\$2^{50}$	NO	$\$0^{10}$	NO	45
SURV ME JR	72	•	•	•	•	•	•	•	•	—	—	•	•	•	•	
RR CE JR	180	•	•	•	•	•	•	•	-	—	—	•	•	•	-	
RR SURV SO	120	CHANGES	NO	BOARD HO	BOARD HO	NO	NO	NOTHING	NOTHING	—	—	—	—	—	NO	46
—	100	—	NO	DORM	—	NO	NO	—	—	—	—	—	—	—	NO	47
AGR	50	—	•	•	—	•	•	—	—	—	—	—	—	—		
SURV 1ST TERM JR	130	CAMPUS	YES	—	—	—	—	—	—	—	—	$\$5^{00}$	—	—	—	48
RR & TOP 1ST TERM SR	175	LEASED LAND	•	—	—	—	—	—	—	—	—	—	—	$\$0^{60}$	—	
SURV CE SO.	288	BLACK HILLS	NO	BOARD HO	BOARD HO	NO	NO	—	—	$\$5^{00}$	$\$2^{00}$	—	0	$\$3^{50}$	YES	50
SURV EE	96	•	•	•	•	•	•	—	—	•	•	—	•	•	•	
SURV EM	144	•	•	•	•	•	•	—	—	•	•	—	•	•	•	
SURV ME FR	36	ON CAMPUS	—	—	—	—	—	—	—	—	—	—	—	—	—	52
SURV CE SO.	96	NEAR COLLEGE	NO	HOTEL	HOTEL	—	NO	NOTHING	—	$\$9^{00}$		$\$2^{00}$	—	NONE	YES	53
SURV OTHERS SO	48	•	•	•	-	—	•	•	—	•		•	—	•	•	
SURV	288	ON CAMPUS	•	DORM	—	NO	NO	NOTHING	NOTHING	$\$4^{50}$	$\$1^{75}$	NO	$\$1^{00}$	NO	YES	55
SURV SO CE OPT	80	NEAR COLLEGE	NO	DORM	BOARD HO	NO	NO	—	—	—	—	—	—	—	NO	56
SURV SO	140	WINFIELD, LA	NO	PRIVATE CAMP	PRIVATE CAMP	NO	NO	BLANKETS, LINEN, TOWELS, ETC	COTS (ONLY)	$\$4^{20}$	NO	$\$3^{75}$	—	$\$7^{50}$	—	57
RR JR	140	•	•	•	•	-	•	-	•	•	•	•	—	•	—	
INE SURV CE EM JR	300	VARIOUS MINING CAMPS	NO	TENTS		NO	NO	NOTHING	NOTHING	$\$7^{00}$	NO	NO	NO	$\$3^{00}$	NO	58
SURV 3RD TERM FR	180	NEAR UNIV.	NO		SCHOOL	NO	NO	•	NOTHING	$\$2^{25}$	$\$7^{00}$	$\$2^{50}$	NO	NO	NO	59
P SURV 4TH TERM FR	180	•	•	•	•	•	•	•	•	•	•	•	NO	•	•	
R 1ST TERM SO.	180	•	•	•	• •	•	•	•	•	•	•	•	$\$0^{50}$	•	•	
NOTE:- Expect to Start Camp in 1916																61
NOTE:- Should Have Six Weeks																62
R.R. JR	192	—	—	—	—	—	—	—	—	—	—	—	—	—	—	63
SURV SO	250	DEVILS LAKE, WIS	STATE PROP	TENTS	HOTEL	YES	YES	BLANKETS, LINEN, TOWELS, ETC	CAMP OUTFIT	$\$7^{00}$	0	$\$1^{75}$	$\$3^{00}$	$\$1^{25}$	NO	64
NOTE:- Railroad Camp Under Consideration																
TOP SURV SO	180	CITY PARKS		BOARD HO	BOARD HO	—	—	—	—	—	—	—	—	—	—	66
GEOD JR	166	•		•	•	—	—	—	—	—	—	—	—	—	—	
R.R. 1ST TERM JR	180	CHAFFIN, MASS		TENTS	SCHOOL	—	NO	BLANKETS, LINEN, TOWELS, ETC	CAMP OUTFIT	$\$3^{00}$	0	0	—	$\$0^{30}$	NO	
NOTE:- Experience Gained In Practical Work																67

s Tents, Cots, Etc. But Not Blankets

No Reply Was Made

e Year Mentioned

HOOL OF YALE UNIV has recently purchased a camp site

DISCUSSION.

Professor O. M. Leland: If I might offer a suggestion, in view of the fact that the report is not supposed to be complete, I should like to say that in some cases here, a different basis of comparison would be better, perhaps, as regards the amount of time devoted to the different kinds of surveying courses at the various institutions. In the first place, on the last page there is a tabulation regarding field practice, which pertains particularly to summer schools of surveying; and I think here it would be important if the number of weeks of attendance might be indicated, as well as the number of actual hours, because in some cases the day is much longer for one institution than for another. For example, in some cases work is done on the campus, and is embraced here in the summer school of surveying. In case of work done on the campus, the chances are pretty great, I think, that the day lasts from about eight o'clock in the morning to five at night, with no evening work; whereas work at camp would probably include work from seven to five, with two or three hours' work in the evening. I think that an addition there of the number of weeks required for attendance at camp would be useful.

Then, if we could have some more information regarding the summer schools that are not held at fixed locations—those that are held at different places in the country—with regard to the plans on which these places are selected; as to whether they are selected accidentally, or whether systematic surveys are carried on from year to year and the camps therefore are in contiguous areas, one of which is surveyed each year; I think this might be interesting information.

If we could get a tabulation in addition to this, which would show how many hours are devoted to a certain number of branches of surveying at different institutions—this would be helpful. The attempt has been made here apparently to do something of this kind; but it seems to me to be hardly complete enough or in sufficient detail so that comparisons could be made. I think a couple of tables arranged on that basis would be of service, that is, showing for instance how many hours are devoted to elementary surveying, how many to plane surveying, mine surveying, city surveying, or geodetic surveying. I think detailed information here is hardly sufficient for a reasonable comparison, because in many cases apparently the reports were on the subject as a whole, and in other cases the reports were on various parts of the subject. Both are shown here.

REPORT OF COMMITTEE ON MECHANICAL ENGINEERING.

Committee No. 16.

BY A. M. GREENE, JR.

The chairman of the Committee makes this progress report on the present condition of shop practice in engineering schools of the United States. The Committee has not had this report to discuss and it is to be considered merely as a report of progress.

The report is based on forty-seven replies to a questionnaire of forty-six questions sent to about ninety institutions in the United States. The answers came in very slowly and in some cases objections were made to the length of such questionnaires, but in most cases there was an endeavor to give as much information as possible. The questionnaires were accompanied by a letter asking for sets of blue prints, reports, notebooks, or other matter showing the method of carrying on the work in the shop. Your Committee has received so few returns from this letter that no analysis could be made of this phase of the Committee's activities. The report will deal only with the analysis of the replies to the questionnaire. The questionnaire as sent out is given on pages 724 to 727 of the June (1916) *Bulletin*. It is to be remembered that this report gives the present status of shop work in the technical schools of the United States.

The reasons given for including shop work in engineering curricula vary with the institution. In the largest number of cases, however, the reasons are: The knowledge of manufacturing operations and of limitations of tools and materials to apply later in design and the training of the student in shop methods. A number of other reasons were given: to conform to custom; to give some idea of mechanic arts; to enable the student to enter commercial shops; to enlist enthusiasm in young students; to impress the value of time and head work in production; to teach students to read drawings and to understand the value of dimensions; to develop manual accuracy and confidence; to broaden the student's viewpoint; to teach the principles of management; to train students in human engineering; to train them in computing manufacturing costs; to demonstrate the principles of the transfer of thought and the transfer of skill; to give mental training; to train men to think clearly on any one subject and to properly supervise and direct work; and to train them to be observant.

In most cases the aim has been for mental trainings rather than manual dexterity although in some cases the object has been merely acquisition of knowledge. In a few cases those answering question 27 placed manual skill above mental training.

That the shop is fulfilling its mission is shown in various ways as indicated by the answers to question 28. The proof is shown by the following: The experience of students after graduation; by work in design courses in the technical schools; by the work done in connection with thesis work; by the positions as journeymen secured by engineering graduates; by positions attained by graduates; by the difference between the work done by graduates of engineering schools and by those from classical courses; by the statements of graduates; by the ability of certain graduates as designers and by the progress made by graduates of engineering schools.

The traditional shop course does not prepare the student to face modern industrial conditions in the opinion of most of those answering, although a few answered in the affirmative. In explaining the answer, however, almost all believe that with little extra work the graduate can enter modern industrial life with success.

To carry out the work in the shop different amounts of time are required by different institutions and moreover the amount of time given to men in the different courses varies. The students of mechanical engineering and of electrical engineering receive the same amount of shop training in most institutions although in some institutions the electrical engineering men receive less training. The work for those in civil engineering, chemical engineering, architecture, mining engineering, agriculture and ceramics is much less, being nothing in many institutions.

The total amount of work averages 512 actual hours, varying from 1,328 hours to 270 hours. The work of the various years is given in the table below:

	Average.	Maximum.	Minimum.
Freshman year	171	360	0
Sophomore year	180	400	0
Junior year	117	400	0
Senior year	44	256	0

This time is made of periods varying from 2 hours to 8 hours per day. When the longer period is used the shop work is done in the summer or in a special term.

The work includes joinery, pattern making. foundry, forging and machine work. In some institutions heat treatment of steel, metallography, machine tool construction, shop methods of time study and cost study with shop management are included in the shop work, while in one institution plumbing is given. The sequence of the work varies although the order given above is quite common. Half of the work is often devoted to the machine shop, a quarter to the wood shop, one eighth to the forge shop and an eighth to the foundry.

Instruction in most institutions is individual. supplemented by class lectures and demonstrations. The work is mostly of small size to illustrate principles, although some commercial work is done by certain institutions and in a number of schools machines or machine parts are made during the shop course. In very few cases the product is classed as large.

In this work 71 % of the institutions require some collateral or preparatory reading and only 33 % require a systematic course of reading or study in connection with the work of the shop. One third of those reporting require written reports on notebooks on the shop work or reading.

The instruction is done in sections, averaging twenty-two men per instructor, varying from 8 to 35. The number of instructors in shop work in an institution varies from 1 to 13, while the number of students taking shop work in any one year varies from 25 to nearly 1,000.

The product of the shop in most cases is scrapped, although students in certain schools are given their work or may purchase it by paying for the material. In a few schools the work is done on a commercial product sold by the school.

The degree of accuracy demanded in this work is different in different schools. In most cases 0.001″ to 0.002″ is required in the machine shop, 1/64″ in the wood shop and 1/32″ in the forge shop. In some cases accuracy in dimensions is not required, form being the important consideration. The finish usually required is best described as commercial finish, varying with the kind of work.

To determine whether or not a student should receive a passing grade for shop work, a definite number of hours of work is required by some, while others require a definite amount of work. In some institutions the judgment of the instructor on an indefinite amount of work during a definite number of hours is used to determine this. In some institutions the ability to solve shop problems is used as the criterion. The grades of the students are mostly reported by a system of letters, each letter having a numerical meaning. In quite a number of cases, however, the percentage method is used. In most cases a grade of below 60 per cent. requires a repetition of the course while a mark below 70 per cent. requires another examination.

The value of the apparatus in various shops is reported to Committee as given in following table in round numbers:

	Average.	Maximum.	Minimum.
Wood shop	$ 4,000	$14,000	$5,000
Machine shop	11,300	13,000	2,000
Foundry	2,100	9,000	400
Forge shop	2,500	6,200	500
Miscellaneous tools	2,000	10,000	200

In most institutions all tools are used by students although in certain ones, some tools are used only for demonstration and some for regular work are operated by the instructors only. These machines include band saws, circular saws, swing saws, jointers, automatic screw machines, universal grinding machines, heat treatment apparatus, knife grinding machines, and some tools used for repair work.

In most school shops the checking system is used in issuing tools from the tool room. This room in some cases is in charge of the students. The students are supplied with tool kits in some institutions. These contain the necessary tools for most of the work but extra tools can be obtained from the tool room. The tools are sharpened by the students in most cases although in a few institutions all sharpening is done in the tool room by those in charge of this work, sharp tools being issued to replace dull ones when these are returned. Instruction in the principles of sharpening is given before the student does any of this work.

The reports show that summer work in commercial shops is required for some, arranged for by others and in many cases it is not cared for or thought desirable. Very few give credit for this work.

Most of those answering the questionnaire think that although shop operation should be learned, the operation of machines is important to the engineer.

Although some insist that the elements of time and cost should be considered, others believe that students can not properly appreciate these elements. Most of those answering believe that good work may be done in shops equipped with old or obsolete machines with the proper instruction. This same opinion is held in regard to methods which are not equal to commercial practice. In all cases except one, the work in the various shops is part of a general scheme and the shops are not independent of each other.

About one fourth of the institutions are endeavoring to plan the shop work to train executives. In many of the institutions the problems of shop management are covered in other courses than those given in the shops. One half of the institutions use time clocks and time cards and one sixth of the shops operate the shops on instruction cards and study students' work for fixing time. A few institutions use students as foremen or speed bosses. About one third of the institutions study shop management in the shop, doing this in the senior year and about the same number have done some experimental work in the art of cutting metals. This was done for thesis work or in the junior or senior year. In some cases the shop is used also for determination of power of machine tools.

Although there seems to be no coördination between the shop and other departments in some institutions, there is coordination in most of them. This is between shop work and the departments of mechanical engineering, machine design and drawing.

The answers seem to indicate that the objects of the shop are being accomplished and that the trend of shop instruction is along the lines of modern shop methods and management.

Discussion.

Professor F. C. Caldwell: Professor Greene has said that in most cases the shop work for the mechanical and electrical engineering students is the same. To what extent in the electrical engineering curricula is distinctively electrical shop work included? Also ought not such shop work to be generally required? An electrical engineering student should not graduate without having some familiarity with soldering, wiring, joint making, coil-winding, etc., but generally such work comes, if at all, more or less incidentally rather than as a regular part of the curriculum.

Dean C. L. Cory: I think that we should not only give some shop courses that will be particularly allied to electrical engineering, but I think also that we should give some electrical engineering shop work to our mechanical engineers.

Unless we are careful we are going to again introduce the adjective to the word "engineer" even in our elementary courses, and I do not think this at all desirable.

Recently we have been called upon to open our machine shops to the chemical engineer, the student interested in forest utilization and to a large number of students in agriculture. I do not like to think that any shop courses are given that are necessarily defined by an adjective. I should prefer to see freshman or sophomore in electrical engineering, mechanical engineering, chemical engineering, forest utilization and agriculture have same work in the shop. There is no reason why all of these students should not in the shop learn some of the fundamental principles of electrical machinery. In other words, the shop should be the place to broaden the students' interest rather than direct it in a narrow way to a special line.

Before leaving the floor I should like to say a word about the effect upon the student of the equipment and tools in the shop. I was greatly impressed a few weeks ago by going through some of the machine tool works in Detroit and Cincinnati, and I was told that machine tools made in America are now being purchased for use in the greatest shops abroad. It seems the machine tools made in America are, above all things, constructive, which means that the men responsible for the design of such complicated and delicate equipment not only have great imaginations but extraordinary constructive ability. We must not minimize the value to the student of the opportunity of seeing and using the highest types of machine tools, because by so doing we will tend to develop imagination and constructive ability, at least to some degree.

To develop manual dexterity at one time seemed to be the most important thing in the shops of our engineering schools. Skill in the use of tools is of course worth while, but it certainly should be secondary to the more important development of the consideration of the principles of design and the ability to work out details of a device to accomplish some particular object. By all means let shop work be on a broad basis.

Professor A. J. Wood: At The Pennsylvania State College, all engineering students are required to present official evidence of a total of eighteen weeks of outside summer work in the industries. Three weeks of such work are accepted as the equivalent of one college credit.* If, by his senior year, a man fails to report work for all of the required summer credits, he must schedule approved subjects at the college to meet the deficiency.

I have watched carefully the effect of this training on mechanical engineering students and have frequently been asked, "Does it take the place of the college shops?" My answer is definitely "No." Most of the students get something worth while outside which they do not get in college, but in some cases these students have been led to discount the real value and the real meaning of the college shops. They lose the perspective and confuse the underlying purpose. I take it that the college shop is primarily to teach *why* specific tasks are done in the way prescribed. Manifestly, the college cannot teach a student to be a mechanic nor is that its function; it has no right to make the pretense. On the other hand, it has a function quite independent of the summer work in the industries. Combined with the outside practice work, I find that the boy gets more out of his college shop courses than if the one was taken without the other. One rounds out the other to an extent depending largely on the nature of his outside experience. On the whole, I am led to believe that in most cases the eighteen weeks of outside work has turned out better men than we could turn out by giving the equal number of credits in the college, *providing* it is taken in addition to a well-balanced schedule.

Professor G. R. Chatburn: Is this eighteen weeks required in addition to the regular four years' work in college shops?

Professor Wood: Yes. This is required in addition to the regular semester credits required for graduation.

Professor C. R. Jones: Our practice in West Virginia is somewhat similar to that outlined by Professor Wood. We formerly required outside summer work as an extra to our regular curriculum. In recent years, some differences of opinion have arisen among the members of the faculty as to the educational value of practical work. We had to give alternate courses in the university to take the place of summer shop work for those who could not get outside practice; and the difference in opinion arose as to the value of the work done at the university in comparison with that done outside. We have about reached a compromise plan which I believe will work out pretty well. Instead of allowing credit for the full five hours' required summer practice, we shall require part of the work to be done at the university and part outside. We give credit on the basis of about 3 to 1 in time; that is, it takes three weeks on the outside for a semester hour credit, while ordinarily one can make a semester hour in about a week in the shop. That means for 1 semester hour credit fifty hours in the university shops, or 150 hours in an outside shop. This distinction is made on account of the repetition of work in commercial establishments.

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* For particulars of this work see discussion at the Minneapolis meeting, as given in Vol. 21, 1913, page 359.

In regard to the differentiation between electrical shop work and mechanical shop work, we have had a course in what we call electrical construction which may be taken by electrical students as a substitute for one to three hours of machine shop practice. Electrical students have, in nearly every case, taken advantage of this election. We have not made electrical construction a requirement in recent years, because we have been modifying our electrical shops and we felt that we might not be able to accommodate all applicants until the work has been standardized. We are arranging the work so that, I think, it will now be made a requirement. At least, it will be put in as regular shop work, which may be taken as a substitute for a part of the machine shop work now required.

Electrical students take the freshman and sophomore shop work at the same time and in the same way as students in mechanical engineering. It is only the advanced shop work in which the differentiation occurs. We give a course in sheet-metal working which includes soldering. This is given to both electrical and mechanical engineering students. I have always felt that no student should leave school who could not handle the soldering iron or could not cut out sheet metal for patterns of ordinary difficulty. He ought to be able to make simple apparatus for himself. I find this work very helpful.

Professor E. F. Chandler: I want to endorse what has been said as to the ratio of 3 to 1 between outside and inside work. It is not quite analogous; but I am doing nearly the same thing in North Dakota myself. We have a summer camp plan, which in the case of civil engineering students is, of course, similar to shop. We have so few students unfortunately, or fortunately, that in practically every case I am able in its place to get them out into summer employment which brings in cash. I won't say that it is credited exactly in a three to one proportion; perhaps five to one is the ratio allowed them. They sometimes protest a little, and think they are not getting fair credit; but they make the equivalent all right for they have three months actual work in summer which is many times longer than the supposedly required time in camp.

I tell them they are getting something out of the work which they could not get in any way on the campus; because in this outside work it is a question of efficiency of getting right down to commercial results, whereas the work in school is much of it mere practice, without any definite result. On the other hand, the commercial work is largely repetition, repetition, repetition, until the man can do the work so well and quickly that he earns his pay; but he, perhaps, does not get as much variety in a month of outside work, as he would in a week on the campus, so that he can not receive credit hour for hour.

There are advantages on either side; but I think the scheme of crediting on the adjustable scale, three or four to one, is a proper plan. Once in a while the boy does not or can not get the proper kind of work outside; and in that case he has to put in extra time, in holidays or recesses on the campus to make up his credits. In this way we have been able thus far to escape having the summer camp. That is partly because we have plenty of room on the campus; and are not like universities in large cities, which have other advantages but are obliged to have separately a summer camp. It is very vital to have some outside work. I persuade many of the students to stay out for a year, between the sophomore and junior years or between the junior and senior years, if they have satisfactory work in the interval. They get the most out of their courses in that way.

Professor F. F. Thompson: I think some gain would result if the Committee could get for us a statement of the condition of shop work now, as compared with its condition say five or ten years ago. Is shop work being increased in any degree in the colleges? Is it being decreased? If so—if it is being decreased—in what particular does the decrease occur? What portions of the shop work are retained? What are the reasons why various kinds of shop work have been omitted, and why others have been retained, and remain in the curriculum? I think that would be information of great value to those of us who are interested in engineering courses. We could at least get the opinions of teachers as a whole. As it is now, we get individual opinions from those with whom we happen to come in personal contact.

Professor Greene: In regard to Professor Williston's point, I feel that most of the answers indicated, although they have not said so in substance just what he is pleading for; that most of us are trying to train the imagination by shop work. We say that it is for the purpose of preparation in design work: and that is really to train the imagination so that we can plan properly on paper.

In regard to Dean Cory's question, I would say that no records indicate any difference in the electrical work and the mechanical work, except in hours.

For Mr. Thompson, I will promise that we will get together information such as he desires, which I also think will be very valuable. I believe there are certain papers in the transactions of this Society which will help us on that point. I will also endeavor to obtain the reasons for the omission and retention of certain courses.

REPORT OF COMMITTEE ON ELECTRICAL ENGINEERING.

COMMITTEE NO. 16.

BY C. F. SCOTT.

The Electrical Engineering Committee held several sessions at which the majority of the members were present, and after consideration of various plans determined on the following schedule, which was approved by the other members of the committee. The three items decided upon are as follows:

1. Short contributions to the BULLETIN were invited relating to methods or appliances in electrical engineering instruction. Several have been received and have either been published or await publication.

2. Sequence of instruction in alternating current and in direct current; which should come first? Continuation of discussion from last Convention, to which contributions were invited. One has been received from Professor William Kent. It is as follows:

Prof. C. F. Scott, *Chairman,*

Dear Sir: I notice in the BULLETIN of the S. P. E. E. that you are inviting contributions to the subject of the methods of teaching electrical engineering. Here are a few of my ideas on the subject.

A. Direct current is not a special case of alternating current any more than the silence of a tuning fork at rest is a special case of the sound it produces while vibrating; or than rest is a special case of motion, or than the uni-directional motion of a fly-wheel is a special case of the to-and-fro motion of the ball of a pendulum.

B. Begin the study of electrical physics by taking a tumbler containing acidulated water, a strip of copper and one of zinc, and a piece of copper wire. Show by a galvanometer needle that something is happening in or around the copper wire. Put several batteries in series and in parallel and show the effect on two measuring instruments, voltmeter and ammeter (don't explain these instruments yet). Wrap the copper wire around a thermometer and show heating effect. Short circuit with a thin wire and show light and fusion. Show how the magnitude of these effects depends on the series and parallel arrangement of the batteries. Make and break the circuit and show sparks. Show a horseshoe magnet and its picking up nails. Wrap the copper wire around an iron bolt and show that the bolt becomes a magnet. Make a magnet with a wide flat pole piece, so that it has a magnetic field of uniform intensity over a considerable area. Drag a wire across this field in one direction and show that a direct current is made in the wire. Show that the voltage decreases as the wire passes into a weak portion of the field. Drag the wire across the field again, but in the reverse direction, and show that a similar direct current is produced, but that the galvanometer needle shows that its direction is reversed. Now take two pole pieces N and S, placed some distance apart, and move the wire in a path across the front of one pole and back across the front of the other pole. Show how the direct current of uniform intensity, made while the wire is passing across the middle part of N, is changed to 0 voltage as it passes around the curve at A and increases to V maximum when it gets into the horizontal path above S, and that its direction is reversed. It is now an alternating current of three periods: (1) Direct and positive; (2) Changing from $+V$ to 0 and then to $-V$; (3) Direct and negative. The alternating current is thus a special case of direct current. When the path of the wire is circular the ordinary alternating current is made.

In this way go through the whole series of the important electrical phenomena in an experimental way, so as to give the student clear and fixed conceptions of elementary electrical facts before he is troubled with theory, measurements, mathematics, etc. Then teach electrical engineering, direct current before alternating current, because it is easier and simpler, and does not require higher mathematics. The experimental study of alternating current machines may, however, be carried on at the same time as the experiments on direct current machines, the theory and design of alternating current machines and transmission being postponed till later in the course. (Signed) Wm. Kent.

3. A questionnaire based upon the following: " From your present point of view as you look back upon your life and development while in college, what do you consider benefited you most? Why?

"*First.* In the regular curriculum.

"*Second.* In other phases of your college life.

"Please state the nature of your present work, the name of college and year of graduation."

It was the intention to submit these questions to a few selected graduates capable of forming a worth while judgment and who have been away from college a reasonable length of time. It was anticipated that in the replies received there would be valuable suggestions, both to teachers and to students. The values set upon various elements of college life by the graduate should be a directing influence with the better class of students. The request was sent to a dozen manufacturing, operating or engineering companies. Returns have been received from the Commonwealth Edison Co., the Philadelphia Electric Co., and the Westinghouse Electric & Manufacturing Co.

The individual replies indicate various points of view and will be serviceable when finally classified and summarized.

The report for the Commonwealth Edison Co. concludes with this summary, which is the "General opinion of group of engineers, graduates of Massachusetts Institute of Technology, Armour Institute, University of Illinois, Ohio State University, etc."

What was of most benefit in the college curriculum?

"Mental training acquired through hard study of rather diversified subjects resulting in giving one the ability to comprehend and grasp problems and situations and to study out complex problems."

What was of most benefit of other phases of college life?

"The association with a large number of fellow students in a manner of intimacy hardly possible under circumstances other than college life, resulting in the ability to judge personal characteristics and character in a way that in itself constitutes a liberal education."

CHAS. F. SCOTT,
Chairman.

DISCUSSION.

Professor J. F. Wilson (by letter): It will, I think, be readily agreed that the greatest benefit to be derived from a college curriculum is "mental training acquired through hard study," but there is much disagreement as to the best way in which this training may be acquired. Some decry the teaching of facts; others think too much stress is put on theory. Are not theory and fact coördinate elements in an education, the one dependent on the other? A jumble of words is not a story; neither does an accumulation of facts constitute an education. But a story cannot be written without words, and an education involves a systematic accumulation and arrangement of facts. History loses none of its cultural value because of the emphasis it puts on such facts as Waterloo, Lexington and Appomatox. Electrical engineering should become no less a mental training because it emphasizes such facts as magnetic induction, and deals with the characteristics of machines and materials.

The writer is in hearty accord with Dr. Kent when he advocates the experimental demonstration of the fundamental *facts* of electrical science *before* entering into any theoretical or mathematical study. The fact established by an experiment attracts and interests the student, his mind immediately demands the reasons lying back of the fact and is in condition to do constructive thinking in developing those reasons.

The writer disagrees most emphatically with the idea that direct (continuous) and alternating currents are governed by different laws. The impedance of an electric circuit containing inductance is a function of the frequency of the current flowing in the circuit, and is equal to the resistance of the circuit when the frequency of the current is zero, *i. e.*, when the current is direct (continuous). The mathematical expression representing the law of current flow in an electric circuit is, therefore, independent of the nature of the current.

It is the writer's opinion that fundamental courses in electrical engineering should lay great stress on the following physical facts:

1. The Law of the Electric Circuit, which is applicable to all circuits without regard to the nature of the current.
2. The Law of the Magnetic Circuit.
3. The Law of Magnetic Induction.
4. The Law of Torque.

A thorough understanding of these four laws (which are statements of experimental facts) will enable the student to comprehend and explain the actions of any of the simpler forms of electrical apparatus, and will furnish a firm foundation for any independent investigations that he may undertake.

Professor Alex. Gray (by letter): When, at the beginning of his junior year, the student comes to the department of electrical engineering, he knows the fundamental principles of electricity and magnetism, but he does not know how to control electric currents nor is he at all sure of what is going to happen when he closes a switch. His laboratory work must therefore begin with such experiments as will rapidly give him the necessary confidence in the handling and controlling of electric circuits and machinery. He must therefore begin with d.-c. work, otherwise his attention will be distracted and his mind bewildered by the trick effects of alternating currents.

Since the class work is intimately tied up with that of the laboratory, it also should begin with direct currents and machinery.

It has been suggested that direct currents are alternating currents of zero frequency and that a.-c. circuits should be taken up first and then Ohm's law rediscovered by substituting frequency equal to zero in the general equation of the electrical circuit. The fallacy of this method of starting electrical work is apparent if one is willing to accept the principle that ideas and formulæ should not be developed before the student is ready to make use of them.

Alternating-current work is difficult and easily forgotten, so that the work on a.-c. circuits should not be commenced until the student is ready to apply the ideas developed to a study of a.-c. apparatus. I take it of course that no teacher has the temerity to suggest that d.-c. machines are special types of a.-c. machines and should therefore not be studied except as special cases.

I do not consider it advisable however to leave the study of a.-c. circuits and machinery for the senior year. The work of the junior year should cover both d.-c. and a.-c. apparatus, the course being similar to that which is now given to mechanical engineers, fundamental principles being emphasized and details left for the senior design classes. The advantages of this arrangement of the work are that the student can read technical literature intelligently during the summer months and during the whole of his senior year, he can understand most of what he sees of the electrical work with which he is thrown in contact and he can study intelligently such professional electives as are given during the first term of the senior year.

The following are suggested as the basic courses around which the work of the electrical department can be built.

Junior Year, first term. Review of the fundamental principles of electricity and magnetism; also a study of d.-c. apparatus, leaving the advanced theory of commutation for the senior design class.

Second term. Solution of a.-c. circuits by vector diagrams; also a study of the elementary theory of a.-c. apparatus.

This work can readily be covered in one lecture, one recitation, one problem period and one laboratory period per week.

Senior Year. There should be an advanced theoretical course of two lectures, two recitations, two problem periods and two laboratory periods per week for both terms; also a design class of one lecture and one problem period per week. The work in the design class should not be limited to the design of a single d.-c. generator, but should take up d.-c. machines, alternators, transformers and induction motors in sufficient detail to show the principles involved and above all to show the limitations in flux and current density, in temperature rise and in construction that the designer encounters and which fix the characteristics of the machine.

Professor F. C. Caldwell: The report of the Committee on Electrical Engineering deals with two points: first, the proper sequence of instruction in alternating and direct currents; and second, the relative value of the different elements in electrical engineering curricula as judged by men who have graduated from college.

Taking the second subject first, it seems to me that very little is to be hoped for this class of questionnaire. Most men who have been out of college a few years are little given to analyzing the advantages gained from different parts of their college experience. Again each man naturally looks at the problem in the light of his own experience since leaving college, and does not consider the wide range of activities for which the curriculum must be designed to equip those who go through it. Much better results should be obtainable by means of personal interviews with graduates, and especially with such men as have had more or less extended experience in the use of graduates in varied lines of work.

With regard to the other point, as to the proper sequence of the study of direct and alternating currents; as the question is stated by the Committee, it seems to refer to whether the direct or alternating current phenomena should be first taken up. This seems like setting up a man of straw to knock him down. The elementary theory of direct currents is so much simpler than that of alternating currents that discussion seems of questionable value.

When it comes, however, to the question of the best sequence of the later work—that is, as to whether we should carry the subject of direct currents not only through the elementary phenomena, but also through dynamo machinery before taking up the alternating current work, or whether it is better after studying the elementary phenomena of current, resistance, etc., to then take up alternating currents and carry these along with the more advanced direct current apparatus, and machinery is a matter which might very properly be discussed. Good results have been obtained in both ways. There are, however, some points which indicate the taking up of alternating currents early. The ideas involved are complicated and difficult and need time for assimilation, which may thus be obtained.

Also the too marked differentiation of alternating current from direct current phenomena may be thus avoided.

REPORT OF COMMITTEE ON MINING.

COMMITTEE No. 18.

BY F. W. SPERR.

The Committee on Mining Engineering presents the questionnaire as published on pages 733–737 of the *Bulletin* with the object, as stated, of ascertaining the average of practice in American mining schools, of giving laboratory instruction to undergraduate students. The Committee believes that a knowledge of such average practice will be beneficial to all those who are engaged in teaching mining engineering, and the Committee intends to use it as a basis for further work for the benefit of the members of the Society.

The questions are numerous, but the replies may be short in nearly all cases, yes or no, a check mark, a numeral with two figures at most, and a little more being required for enumeration of apparatus.

DISCUSSION.

H. B. Meller (by letter): I have gone over the Questionnaire very carefully, and would like to say that it covers the ground thoroughly; except for our purposes we would suggest the addition in Table 4 of boring (as distinguished from drilling), coal mining machinery, haulage, hoisting, drainage, and ventilation, in all of which laboratory work can be given. I would suggest also that explosibility of coal dust be separated from mine gases. We so separate them in our work. A division indicating to what extent mining operations are used as laboratory would be useful; also, whether the school has a private mine or tunnel, and to what extent it is used.

Under Division *f*, I assume the Committee means work of the nature of our coöperative summer requirements. I would suggest, also, that a division be added for inspection of mining operations, and another showing to what extent drawings and photographs are used instead of actual machinery. It is quite likely that all of these things have been considered by the Committee, and that those they deem important have been covered under other heads.

REPORT OF COMMITTEE ON STATISTICS.

Committee No. 19.

BY PROFESSOR A. J. WOOD.

The report proper consists of three quite independent parts. The first part has to do with the presentation of statistics on attendance at engineering schools.

The Bureau of Education, Washington, has compiled for use of the Committee on Statistics, attendance records for 125 colleges and universities teaching engineering. A brief summary is presented in the following table.

Engineering Students in American Institutions.

Division of Engineering.	1914–'15.	1909–'10.	1904–'05.
General engineering	6,059	7,096	1,893
Chemical engineering	2,383	869	759
Civil engineering	7,182	7,889	7,356
Electrical engineering	6,637	5,450	5,204
Mechanical engineering	7,751	6,377	6,654
Mining engineering	1,922	2,656	2,547
Other engineering	958		172
Total	32,843	30,337	24,585

The second part of the report concerns itself with subjects still under consideration, principally the question of the relative scholastic standing of students from technical and manual training high schools compared with those from classical and Latin high schools. An early study of this question led to caution. As an example, at the last annual meeting citations were made by our Committee from a report sent out by a certain Massachusetts institution of high standing and which pointed to the general conclusion that students from the classical and Latin high schools showed better scholastic records in college than those from the technical and manual training high schools. On investigation of the high schools from which most of the men entered this school of technology and comparing all of the conditions under which the figures were obtained, it was found unwise and unsafe to draw a sweeping conclusion as to the relative value of the two kinds of training. Local conditions may nullify the force of figures and the use of statistics alone in reaching a conclusion becomes a high crime and a misdemeanor.

An early study of the whole question made it evident that unless we could weigh the mental qualifications of the individual whose scholastic work we were studying, and that this be done in hundreds of cases covering years of student records, and further by taking these records from different parts of the country, no safe and sane conclusion can be drawn. Statistics now in the hands of the committee give an almost equally favorable showing for the advocates on both sides of the question.

The third part of the report is concerned with statistical studies, mainly those relating to scholarship records. The committee finds that many investigations of probable value to other institutions have been made and are available to those wishing to avoid the duplication of statistical work.

On December 15, 1915, a questionnaire was sent to fifty-five representative colleges and the replies from forty-two, as summarized by Professor Hosmer, are presented herewith. The replies indicate that nearly all of the forty-two institutions have under way or have completed studies relating to student scholarship or are making special statistical studies. It is urged that the summary here presented be examined with care by those who desire to obtain information along the lines indicated.

F. A. Fish,
G. L. Hosmer,
J. D. Phillips,
A. J. Wood,
Chairman.

SUMMARY OF REPLIES TO QUESTIONNAIRE SENT BY COMMITTEE ON STATISTICS.

	1	2	3	4	5	6
College or Institution.	Does Your College Keep a Record of the Withdrawal of Students During the Year? (I.)	Do You Keep a Record of the Ratio of Those Who Enter in a Given Class to Those Who Graduate? (II.)	Does Your College Employ an Alumni Secretary? (III.)	What Studies Have Been Made of Student's Scholarship Records? (V.)	If These Studies Are Available to Members of the Society, from Whom May They be Obtained? (VI.)	What Other Statistical Studies Have Been Made? (VII.)
Arkansas, Univ. of (Coll. of Eng.) Fayetteville, Ark.	Yes	No	No	Average grade of all students, of men, of women, of non-fraternity men, of fraternal organizations; grades given by different instructors; proportion of failures, average grades, and high marks.		
Brooklyn Polytechnic Institute.	Yes	No	No	None.	—	None.
Brown University, Providence, R. I.	Yes	No†	Yes	Records of fraternity members and athletes.	Dean O. E. Randall.	Relation of growth of University to growth of population of state; reasons for selecting Brown in preference to some other college; other statistics of purely local interest.

REFERENCES: * Indicates that a secretary is employed by the alumni association. Figures are available from which such a ratio could be easily computed. ‡ Indicates that the alumni association and a board of trustees unite in the employ.

SUMMARY OF REPLIES TO QUESTIONNAIRE SENT BY COMMITTEE ON STATISTICS.—*Continued.*

College or Institution.	1	2	3	4	5	6
	Does Your College Keep a Record of the Withdrawal of Students During the Year? (I.)	Do You Keep a Record of the Ratio of Those Who Enter in a Given Class to Those Who Graduate? (II.)	Does Your College Employ an Alumni Secretary? (III.)	What Studies Have Been Made of Student's Scholarship Records? (V.)	If These Studies Are Available to Members of the Society, from Whom May They be Obtained? (VI.)	What Other Statistical Studies Have Been Made? (VII.)
California, Univ. of, Berkeley, Cal.	Yes	No†	Yes	Relative standing of students from different preparatory schools. Records of fraternal and athletic organizations, etc.	Prof. W. Scott Thomas, University Examiner of schools.	
Carnegie Inst. of Tech., Pittsburgh, Pa.	Yes	Yes	No	Comparative statistics concerning student's preparatory school record and that of his Freshman Year.	John H. Leete, Dean.	Comparison of practice followed by different institutions as regards examinations; studies of employment of graduates; of laboratory methods; of cooperative courses of instruction; financial expenditures, etc., etc.
Case School of Applied Science, Cleveland, Ohio.	Yes	No†	No	Ratio of failures to total number of marks for each department, fraternity, and student organization.	C. S. Howe, Pres.	None.
Cincinnati, Univ. of (Coll. of Eng.)	Yes	Yes	No	Comparison of records of fraternity and non-fraternity men; records of men from local high schools compared with those from out of town schools.	Office of the Dean.	Charts showing growth of Univ. compared with other colleges; increase in students and in number of cooperating firms; reason for withdrawals; etc.

Clarkson College of Tech., Potsdam, N. Y.	No	Yes (10:6)	No	None	—	Data on earnings of graduates.
Colorado State Agr. College, Ft. Collins, Colo.	Yes	No	No	Standing of students, classes and secret societies, distribution of grades.	S. H. Johnson, Dean.	Studies in costs to teach different subjects.
Colorado, Univ. of, (Coll. of Eng.) Boulder, Colo.	Yes	No†	Yes	Average grades of all students, athletes, student organizations, professional societies, fraternities, etc.	Fred E. Hagen Registrar.	
Columbia Univ., New York City	Yes	No†	No*	1.—College rank as compared with rank in entrance exams.	1.—"Educational Review," Sep.,1914,"Educational Administration." (Macmillan & Co.)	Relation of entrance conditions to standing in college.
Florida, Univ. of, (Coll. of Eng.) Gainesville, Fla.	Yes	No	No	Records of candidates for honorary fraternity.	Office of the Dean.	None.
Iowa, State Univ. Iowa City, Ia.	Yes	No†	Yes	(*a*) Studies of time spent in preparation. (*b*) Studies of marking system. (*c*) Relative merits of the lecture and recitation methods. (*d*) The small group vs. the large class.	(*a*) Prof. Irving King. (*b*) Prof. Smith. (*c*) Prof. Higbee. (*d*) Dean Raymond	
Illinois, Univ. of, Urbana, Ill.	Yes	Yes	No	Comparison of fraternities of clubs.	Published in student paper.	

SUMMARY OF REPLIES TO QUESTIONNAIRE SENT BY COMMITTEE ON STATISTICS. — *Continued.*

College or Institution.	1	2	3	4	5	6
	Does Your College Keep a Record of the Withdrawal of Students During the Year? (I.)	Do You Keep a Record of the Ratio of Those Who Enter in a Given Class to Those Who Graduate? (II.)	Does Your College Employ an Alumni Secretary? (III.)	What Studies Have Been Made of Student's Scholarship Records? (V.)	If These Studies Are Available to Members of the Society, from Whom May They be Obtained? (VI.)	What Other Statistical Studies Have Been Made? (VII.)
Kansas State Agricultural College, Manhattan, Kan.	Yes	Yes	No	None.	—	Study of the occupation and distribution of engineering graduates in the various engineering colleges of the U. S. (A. A. Potter, Dean.)
Kansas, Univ. of (school of Eng.) Lawrence, Kan.	Yes	No†	Yes	Study of average standing of individuals and classes; comparison of many groups and divisions.	P. F. Walker, Dean.	Salaries of graduates; Personality of students; etc.
Lehigh Univ., So. Bethlehem, Pa.	No	No	No*	None.	—	None.
Maine, Univ. of, Orono, Maine.	No	No	No	Average grade of student organizations and fraternities.	Published in Alumni Bulletin.	None.
McGill Univ., Montreal.	Yes	No†	No	None.	—	None.
Mass. Inst. of Tech., Boston, Mass.	Yes	No	No*	Relative standing of students, as regards various student organizations, fraternities, etc.	Published in "Technology Review." For reprints, apply to Walter Humphreys, Registrar.	Charts showing distribution of Alumni in U. S., increase in registration, number of graduates by years; registration by courses; number of students from other colleges, foreign students; S. B. degrees, etc., etc. Published in President's Report.

Michigan, Univ. of (Coll. of Eng.) Ann Arbor, Mich.	Yes	Yes	Yes	Per cent. of students with clear records, those with one deficiency, and those with more than one deficiency.	Prof. A. Ziwet.	
Michigan College of Mines, Houghton, Mich.	Yes	No	No	Comparison of fraternity records.		
Minnesota, Univ. of (Coll. of Eng.) Minneapolis, Minn.	Yes	Yes	Yes	For specific information, apply to Mr. E. Durand.	See column 4.	See column 4.
Nevada, Univ. of Reno, Nev.	Yes	No	No*	—	—	Study of grading system to equalize grades given by different instructors.
N.Carolina, Univ. of (school of App. Science), Chapel Hill, N. C.	Yes	No	No	Comparison of fraternity with non-fraternity men; comparison of grades of students from different preparatory schools. Comprehensive study of student grades by divisions and by individual professors and instructors.	P. H. Daggett, Dean.	
Northwestern Univ. (college of Eng.) Evanston, Illinois.	Yes	Yes	No	Average record of each class; comparison of records of working and non-working students; studies of relative standing of students from different high schools.	None of these are in a form which could be placed at the disposal of the society.	

SUMMARY OF REPLIES TO QUESTIONNAIRE SENT BY COMMITTEE ON STATISTICS.—*Continued.*

College or Institution.	1 Does Your College Keep a Record of the Withdrawal of Students During the Year? (I.)	2 Do You Keep a Record of the Ratio of Those Who Enter in a Given Class to Those Who Graduate? (II.)	3 Does Your College Employ an Alumni Secretary? (III.)	4 What Studies Have Been Made of Student's Scholarship Records? (V.)	5 If These Studies Are Available to Members of the Society, from Whom May They be Obtained? (VI.)	6 What Other Statistical Studies Have Been Made? (VII.)
Ohio State Univ., Columbus, O.	Yes	No	Yes‡	(1) Records of 1100 students in freshman chemistry. (2) Mortality of Eng. students.	(1) Prof. W. L. Evans (2) Prof. E. F. Coddington, also Miss E. D. Cookins, Prof. W. L. Evans.	Address chairman of Univ. Statistics, also consult numerous reports by Prof. W. T. Magruder, in Proceedings S. P. E. E.
Oregon Agricultural College, Corwallis, Ore.	Yes	Yes	No	Comparative standing of clubs and fraternities as compared with entire student body.	Prof. T. D. Beckwith.	Preparation of entrants, student self-support; student honor system; faculty adviser system; etc.
Pennsylvania State College, State College, Pa.	Yes	Yes	Yes	Professional and Geographical Distribution of Engr. School graduates of Pa. State College (Dean Sackett).	Penn. State Alumni Quarterly.	None.
Pittsburgh, University of	Yes	Yes	Yes	Studies of Freshmen and High School Records, Fraternity members, etc.	F. L. Bishop, Dean	Cost of Institution, salaries of coöperating students and graduates, honor men from high school, etc.
Pratt Institute, Brooklyn, N. Y.	Yes	Yes	No*	—	D. E. Rice, Secretary.	Incomes of graduates; relation of grades in college to success after graduation; apportionment of study periods among different subjects.

Purdue Univ., LaFayette, Ind.	Yes	Yes	Yes	Relative standing of fraternities.	E. H. Davis, Registrar.	See President's report.
Rensselaer Polytechnic Institute, Troy, N. Y.	Yes	No	No	None.		
Rose Polytechnic Institute, Terre Haute, Ind.	Yes	Yes	No*	Fraternity and athletic records.	C. L. Mees, Pres.	
Stevens Institute of Technology, Hoboken, N. J.	Yes	Yes	No*	Records of student organizations.	Published in student's Handbook.	Studies of honor system, and student self government.
Tufts College (Engineering School), Tufts College, Mass.	Yes	Yes	No	Comparative records of results of meetings of Committee on Promotions, in the matter of probations, warning, etc. Study of lowering of scholarship during sophomore year. Percentage of low marks and failures.	G. C. Anthony, Dean.	Alumni statistics, charts of employment, etc.
Vanderbilt Univ. Nashville, Tenn.	Yes	No†	Yes	Records classified (*a*) according to preparatory schools attended; (*b*) according to fraternities.	W. H. Schuerman, Dean,	None.
Washington, State College of, Pullman, Wash.	Yes	No.	No	Comparative studies of fraternities and clubs.	—	Percentage of students who fail to return each year.
Washington, Univ. of, Seattle, Wash.	No special	No	No	Studies of grades for honors, etc.	Available through Registrar.	

SUMMARY OF REPLIES TO QUESTIONNAIRE SENT BY COMMITTEE ON STATISTICS.—*Continued.*

College or Institution.	1	2	3	4	5	6
	Does Your College Keep a Record of the Withdrawal of Students During the Year? (I.)	Do You Keep a Record of the Ratio of Those Who Enter in a Given Class to Those Who Graduate? (II.)	Does Your College Employ an Alumni Secretary? (III.)	What Studies Have Been Made of Student's Scholarship Records? (V.)	If These Studies are Available to Members of the Society, from Whom May They be Obtained? (VI.)	What Other Statistical Studies Have Been Made? (VII.)
West Virginia Univ. Morgantown, W. Va.	Yes	Yes	No	Comparison of fraternity records, and non-fraternity records.	Dr. A. M. Reese.	None.
Wisconsin, Univ. of, Madison, Wis.	Yes	No†	Yes	Total number and percentage of students receiving grades of Excellent, Good, Fair, Poor, Condition, and Failure; comparison of mid-semester with semester grades; comparison of records made by students from different localities and different schools; number and percentage of students warned, placed on probation, continued on probation, advised to withdraw, and dropped at the end of each semester.	The results of these studies are at the disposal of the society, if they are combined with statistics from other institutions, no mention being made of this institution.	None of general interest.
Worcester, Polytechnic Institute, Worcester, Mass.	Yes	Yes	Yes	None.	—	Study of employment of students, and having conditions.

REPORT OF COMMITTEE ON STANDARDIZATION OF TECHNICAL NOMENCLATURE.*

Committee No. 20.

BY J. T. FAIG.

About eighteen months ago your Committee on Technical Nomenclature compiled reports of the various national societies—the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Electrical Engineers, and so on—into one report, which was presented a year ago as a report of progress. That report was mimeographed and sent to about one hundred engineers, teachers, writers, and publishers. Criticisms and suggestions were received from quite a number of them, and these were compiled in the following manner: A card was assigned to each word, and all criticisms relating to that word were put on the card. All the criticisms of each word were in one place, and could be easily studied. The differences of opinion shown by the data were amazing. The following examples show typical instances.

The word "clutch-coupling" appeared in the list with a hyphen. The word "clutch pulley" appeared without a hyphen. We received many suggestions that the term "clutch-coupling" should have the hyphen removed, and many suggestions that the term "clutch pulley" should have the hyphen inserted. "Cut-off" was sent to us spelled in three different ways. We could find no real concensus of opinion as to the hyphenating of "high-priced." Really, you cannot imagine the utter chaos which exists unless you will go through the evidence that is shown on the cards that I have here. Chaos is the only word to describe the condition of the data; it seemed almost structureless. So the rules formulated by the Committee in an attempt to show the tendency of technical nomenclature, which appear on page 243, are suggested in fear and trembling. I will read the paragraph preceding these rules, so that you will understand that they represent merely our effort to express general tendencies.

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* See also Engineering Education, June, 1916, p. 738.

"The following rules represent an effort to express the general tendency shown in the criticisms of the preliminary report of 1915. It must be borne in mind that the differences of opinion shown by the cards preclude the possibility of formulating any set of rules that will secure universal approval. The rules allow sufficient latitude to harmonize existing differences until entire conformance with them, or some other set of rules, is secured."

You will observe that the rules relate principally to the use of the hyphen. There is a reaction against the use of the hyphen in technical nomenclature. That stands out, unquestionably. I have the evidence of it here. (Showing cards and letters.)

Please do not understand that the Committee is suggesting its own rules. The Committee is trying to present what appears to be the trend or tendency to you. My purpose this morning is to find whether the rules suggested agree with your views or not.

On page 244 we have a list of words which the Committee presents as approved by them. I wish to call your attention particularly to the fact that the second list, beginning on page 249, is not approved by the Committee. This does not mean that it is disapproved by the Committee. It means that we have gathered these words from everywhere. The figure at the end of the line indicates the place the word came from. We offer both lists for suggestions and criticisms. Later on you will be asked to send criticisms of these words to the members of the Committee. If you approve of them, say so; if you do not, say so. The idea of the Committee is simply to find out the one best way to spell, to abbreviate, or to hyphenate, a word. I hope I have presented the matter in such a way that those who are interested in it may understand how the data were obtained.

I will say that of the three rules on page 243, I think the third is probably open to some question. Please understand that when we state the tendency of technical writers, we do not mean to say that the majority are for that thing. We simply record that the responses indicate tendencies along certain lines. The purpose of the discussion on this report is to find out the strength of these tendencies.

It is easy to formulate a report. It will be extremely difficult to secure the acceptance of any report on technical nomenclature. The best way to get a man to accept it is to get him to help you with it. That disarms him almost at once. Furthermore, when he finds you are willing to take him into your confidence, he makes up his mind that you are not trying to put something over on him. The publishers of the country, editors, and secretaries of societies have shown a fine spirit of coöperation. I suggest, Mr. President, that our Society request that the national engineering societies each select two men to coöperate with the Committee of this Society on technical nomenclature, in an effort to get acceptance among technical men, of standard forms for the spelling, hyphenating, and abbreviating of disputed technical terms.

Rules for Compound Technical Terms.

1. Omit hyphens with compound nouns. Example, *railroad.*
   Exceptions:
   - (*a*) When a compound noun is composed of two or more words, each of which is a distinct engineering unit. (As *kilowatt-hour, ton-mile.*)
   - (*b*) When a term that should be written as one word cannot be so written because of the awkward appearance it would present. (As *straightedge.*)
2. Do not write a compound noun as one word unless it is so given generally in dictionaries. Example, *boiler room.*

Exceptions:

(*a*) When the term is a scientific unit. (As *candlepower, horsepower.*)

*3. Omit hyphens with adjective compounds, except when the meaning is not clear without the hyphen. Exceptions usually fall under two heads.

(*a*) Where ellipsis occurs. (As *first-class.*)

(*b*) Where the adjectives separately fail to convey the correct meaning. (As *water-tube* boiler.)

The following words are approved by the Committee as to spelling, hyphenating, and abbreviations. It is recommended that the forms shown be adopted for all publications of the Society and that members be urged to use them in their notes, articles, and books.

THESE WORDS ARE APPROVED BY THE COMMITTEE.

air compressor		4
alloy steel		1
adjustable-speed motors	(adjustable-speed as adjective)	9
alternating current	spell out (a.c. when used as a compound adjective)	8
ammeter		9
amperes	amp., or spell out	
asphaltic contents		10
bevel gear		4
blister bar		1
boiler horsepower	boiler hp.	
boiler room		4
brake horsepower	b. hp.	
British thermal unit	B.t.u.	3
Brown and Sharpe gage	B. & S. gage	
candlepower	cp.	

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* "By action of the Society at the annual meeting in June, 1916, this rule was changed to the following:

"3. Use hyphens with all adjective compounds. Example, *water-tube boiler.* This necessitates changing to *coke-oven tar, counter-clockwise convention, high-pressure cylinder, hot-water heating system,* the corresponding forms shown in the approved list."

These words are approved by the Committee:

carbon steel	as noun	1
cast steel	as noun or adjective	4
cast iron	as noun or adjective	1, 4
cement bar		1
Celsius	C.	3
centimeters	cm.	8
circular mils	cir. mils (c.m. in tabular matter)	8
clutch coupling		
clutch pulley		7
coal tar	as noun	10
coke-oven tar		10
compound gears		2
cone gear		2
connecting rod		4
constant-speed direct-current motors		
constant-potential transformers		9
constant-speed motors	(constant speed as adj.)	9
continuous current	as noun	9
converted bar		1
counter-clockwise convention		
counter--electromotive force	counter e.m.f.	8
crank pin		4
crank shaft		4
cubic	cu.	8, 3.
cut-off		4, 7.
diameter	spell out	8
direct current	spell out (d.c. when used as compound adjective)	8
drafting room		4
electric horsepower	e. hp.	
electromotive force	e.m.f.	8, 3
engine room		4
equivalent sine wave		9
face gear		2
Fahrenheit	F.	
ferro alloys		1
feet	ft.	8, 3
figure	Fig.	3
fire tube	as noun	4
flywheel		7
follower guide		2
follow rest		2
foot-pounds	ft-lb.	8, 3

These words are approved by the Committee:

gallons	gal.	3, 8
gas engine		4
gas producer		4
gas regulator		4
gas turbine		4
gear guards		2
grains	gr.	3, 8
gram-calories	g-cal.	
grams	g.	8
gray cast iron		1
headstock		2
high-duty	as adjective	4
high-pressure cylinder	spell out	3
high-priced		4
high-speed		4
horsepower	hp.	
horsepower-hours		
hot-water heating system		4
hot well		
hours	hr.	8
inches	in.	8, 3
index plate		2
indicated horsepower	i. hp.	
induction generator		9
induction motor		9
ingot iron		1
ingot steel		1
iron castings		1
kilogram	kg.	8
kilogram-meters	kg-m.	8
kilometers	km.	8
kilovolts	kv.	8
kilovolt-amperes	kv-a.	
kilowatts	kw.	3
kilowatt-hours	kw-hr.	
lathe bed		2
latent heat		4
linear	lin.	3
liquid asphalt	do not use	10
live-center		7
load factor		9
low-duty	as adjective	4
machine shop		4

These words are approved by the Committee:

magnetomotive force	m.m.f.	3, 8
malleable cast iron		1
mean effective pressure	m.e.p. in tabular matter	3
meters	m.	8
meter-kilograms	m-kg.	8
microfarad	spell out	8
miles	mi.	8
miles per hour per second	mi. per hr. per sec.	8
milligrams	mg.	8
millimeters	mm.	8
minutes	min.	3, 8
mixer metal		1
motor generator		9
mottled cast iron		1
multiple cylinder		4
multispeed motors		9
non-inductive load and inductive load		9
ohms	spell out	8
oscillating current		9
passenger car		4
per	spell out	8, 3
per cent	spell out (% in tabular matter)	3
percentage	per cent (% in tabular matter)	8
per cent drop		9
phase difference		9
pig iron		1
piston rod		4
plant factor		9
plated bar		1
pounds	lb.	8, 3
power factor		9
power plant		4
printing press		4
railroad car		4
revolutions per minute	rev. per min. (r.p.m. in tabular matter)	8
rod mill		4
rolling mill		4
second	sec.	3
semi-steel		
shear steel		1
short-circuit stresses		9
sine wave		9

These words are approved by the Committee:

specific heat		4
spindle feed gears		2
spur gear		4
square	sq.	8, 3
stay bolt		4
steam heating or heat		4
steam piping or pipe		4
step bearing		4
steam boiler		4
steam jacket		4
steam power plant		4
steam turbine		4
street car		4
street railway		4
stud gear		2
ton-mile	spell out	8
tons	spell out	8
tool block		2
tool post		
unipolar machines		9
United States gallon	U. S. gal.	3
valve gear		4
varying-speed motors		9
volt-amperes	spell out	8, 9
volts	spell out	3, 8
water meter		4
water power		4
waterworks		
watt-hours	watt-hr.	
watt-hour meter		9
watts	spell out	3, 9
watts per candlepower	watts per cp.	
white cast iron		1
wood block pavement		10
worm gear		4
wrought iron		4, 1
yards	yd.	8, 3
yield point		4

Miscellaneous Forms.

3 in. by 6 in.	7
3 in. long	7

These words are approved by the Committee:

3-in. valve	3-in. as adjective	7
one twenty-fifth		7
three sixteenths		7
three hundred twenty-two		7
twelve-inch main		7

1. From the report of committee 24, on uniform nomenclature of iron and steel, International Association of Testing Materials, Eighth Congress, New York, 1913. (Not accepted.)
2. Preferred names for lathe parts as determined by a ballot of builders of lathes. See *American Machinist,* April 24, 1913.
3. From the report of a committee to co-operate in standardizing abbreviations, symbols, punctuation, etc., in technical papers. *Proceedings of the American Society of Civil Engineers,* April, 1904 (Volume XXX, No. 4), pp. 174–177.
4. Taken from an old style sheet of the American Society of Mechanical Engineers.
5. From C. B. Going, editor, *The Engineering Magazine.*
6. Suggested by Mr. D. M. Wright.
7. From a list prepared by W. P. Cutter, librarian of the Engineering Societies. 29 W. 39th Street, New York.
8. A. I. E. E. standard abbreviations and notation, edition of February, 1913.
9. From Standardization Rules of the American Institute of Electrical Engineers. Edition of December 1, 1914.
10. Suggested by Mr. W. W. Crosby.

The following list of words has been compiled from various sources, many of which are indicated. These are to be considered by the Committee and such of them as are deemed worthy will be placed upon the approved list in later reports. Words marked * appeared in the preliminary report of 1915. but have not yet been placed on the approved list.

These Words Have Not Been Approved by the Committee. They Are Given for Criticism and Suggestions.

aboveboard		11
absolute	abs.	14
acid-proof		11
airbound		11
air chamber		13
airdriven		11
air pump		13

These words have not been approved by the Committee:

airship		12
alcoholimeter		11
alcoholmeter		11
aline	not align	11
all-around		11
allbone		11
all-possessed		11
all right	not alright	12
allspice		11
aluminum		11
amidships		11
American Iron and Steel Institute	Am. Iron & Steel Inst.	14
amperemeter		11
amperometer		11
American Railway Engineering Association	Am. Ry. Eng. Assn.	14
anchor-hold		11
antilogarithm of	antilog.	14
approximate	approx.	14
arc lamp		13
armor-bearer		11
armor-clad		11
armor-plated		11
around	not round	11
arrowbeam		11
asked-for opinion		11
American Society of Mechanical Engineers	A.S.M.E.	14
atmospheres	atm., atmos.	14
auxiliary	aux.	14
average	avg.	14
avoirdupois	avoir.	14
ax	not axe	11
Babbitt metal	not Babbit metal	11
backfire		13
back-gear handle*		2
backlash		12
back-rest		12
back-shaft		12
balance wheel		13
ball-and-socket joint		18
ball bearing		13
ball-peen		12
barometer	bar.	14

These words have not been approved by the Committee:

base-burner		11
baseplate		12
bathroom		11
bathtub		11
battleship		11
Baumé	not Beaumé	11
barrels	**bbl.**	14
Baume (degrees)	**Bé.**	14
bedplate		15
bedrock		15
bellcrank		12
bell-mouthed		12
belt drive		12
benzin	not benzine	11
beveled	not bevelled	11
Birmingham gage	**B. G.**	14
bib cock		11
Birmingham	**Birm.**	14
blacksmith		11
blacksmithing		11
blast furnace		13
blank-holder		12
blow-hole		12
blowoff		15
blow-off		11
blow-out		11
blowpipe		12
blue print*		4
boathouse		11
boilermaker		12
boilersmith		11
bonus		16
bookbinder		11
boring-bar		12
boring machine*		6
box-tool		12
brakeshoe		15
brasswork		15
brickbat		11
brickkiln		11
bricklaying		11
brickmaker		11
briquet	not briquette	11

These words have not been approved by the Committee:

briqueted		11
briqueting		11
bromid		11
bromin		11
bushels	bu.	14
bucketful		13
built-up		11
bulb-tee		11
bulkhead		13
Bulletin	Bull.	14
Bunsen burner		11
bur	not burr	11
burden		16
burnt alum		11
busbar		13
Birmingham wire gage	B. W. G.	14
center to center	c. to c.	14
cubic centimeter	c. c.	11
cabinetmaker		11
calories	cal.	14
camshaft		15
cam-shaft		12
can not		11
canoewood		11
cantaliver	not cantilever	11
capscrew		15
cap-screw		12
carbid	not carbide	11
carbureter	not carburetter	11
carbureting		11
cardboard		11
carload		11
carman		11
carriage-way*		10
caseharden		12
cast-weld		11
catalogue	not catalog	12
C-clamp		12
center	not centre	11
centerbit		11
center-fire		11
centerline		17

These words have not been approved by the Committee:

center line		12
center-rest		12
cesspool		11
centrifugal force	C.F.	14
cubic feet per minute	c. f. m.	14
center of gravity	C. G.	14
centimeter-gram-second	c. g. s.	14
chainsmith		11
change-gear box*		2
chauffeur		11
cheap-john		11
check-nut		12
checkwork		11
cherry-wood		11
cheval-vapeur		11
chlorid		11
chlorin		11
cast iron	C. I.	14
classman		11
clay-working machinery*		6
clevis		11
cloakroom		11
clockwise		11
clockwork		11
coal dust		13
coefficient	coeff.	14
cogwheel		11
column(s)	col.	14
cold-drawn		11
cold-rolled		13
cologarithm of	colog.	14
compound	comp.	14
concentrated	conc.	14
condensing	cond.	14
condensable		11
conductible		11
connectible		11
control		16
controllable		11
conveyer	not conveyor	11
cone-shape		12
constant	const.	14
coöperate	not co-operate	11

These words have not been approved by the Committee:

copper-zinc		18
corkscrew		11
cosine of	cos	14
arc whose cosine is	cos^{-1}	14
anticosine of	cos^{-1}	14
inverse cosine of	cos^{-1}	14
cosecant of	cosec	14
inverse hyperbolic cosine of	cosh^{-1}	14
cost-keeping		13
cost reduction		13
cotangent of	cot	14
cottonwood		11
counterbalance		12
counterbore		12
counter-revolution		11
countershaft		17
coversed sine of	covers	14
craneman		11
cribwork		13
crossbar		11
crossbeam		11
crosshead		12
cross-peen		12
cross-rail		12
cross-section		12
crosswise	not crossways	11
cup-wheel		12
cutter-head		12
cutter-spindle		12
cyanid	not cyanide	11
cylinder	cyl.	14
deckle-edged		11
degrees	deg.	14
definition(s)	def.	14
diagrammatic	not diagramatic	11
die-bed		12
die-head		12
die-holder		12
dieing machine*		6
diemaker		12
diesinker		11
difference	diff.	11
dimension line		17

These words have not been approved by the Committee:

direct-connected engine*		7
direct-current compensator*		9
direct-current generator*		7
disk	not disc	11
dispatching		16
distance	dist.	14
distributed	dist.	14
distributer	not distributor	11
double-shear steel*		1
double track		13
dovetail		10
downdraft		17
downward	not downwards	11
draft		11
drafting board		13
draftsman		11
dragbar		11
drag-saw		11
dram	not drachm	11
drawbar		11
drawing-room	use drafting room	11
drier	not dryer	11
drilling machine*		6
drivebolt		11
driveshaft		17
drop-forging		12
drop-of-potential		13
drop-press*		4
dry-clean		11
dry-grind		11
dust guard		13
dustproof		12
eagle-sighted		11
effective horsepower		
efficiency	effy.	14
elastic limit	E. L.	14
electric	elec.	14
electro-engrave		11
electro-etching		11
electrolysis		11
electrolyte		11
electromagnet		12
electroplate		12

These words have not been approved by the Committee:

ell		12
embedded	not imbedded	11
emery wheel		12
E. M. F.	not e.m.f. or E.M.F.'s	11
employee		11
end-mill		12
end thrust		13
end-thrust		12
endwise	not endways	11
engineman		13
escapement wheel		13
evaporation	evap.	14
everyday		12
everyone		12
exempli gratia	e. g.	11
exhibitor		11
exponential function of	exp.	14
extension line		17
exterior secant of	exsec	14
eye-bar*		4
eyebeam		11
eyebolt		11
eyeleted		11
eyepiece		11
fabrikoid		11
face-arbor		11
face-harden		11
faceplate*		2
falsework		13
farther (distance)		11
feed		16
feed-box		12
feed-gear segment*		2
feed-rod gear*		2
feed-shaft		12
fiber	not fibre	12
finish-grind		12
finish-turn		12
fireback		11
firebox		12
firebrick		12
fireclay		12
fireproof		12

These words have not been approved by the Committee:

fivefold		11
five-leaf		11
flareback		11
flashlight		13
fluework		11
free on board	F. O. B.	14
fool-proof		12
footbridge		11
footgear		11
footnote		11
foot-pound-second		11
footway*		10
foreman		13
former pin		12
framework		11
freeboard		11
freehand		17
freezing point		13
fretwork		11
friction clutch		13
frustum	not frustrum	11
factor of safety	F. S.	14
gangway		13
gas-fired		11
gas-house coal tar*		10
gasify	not gasefy	11
gaslight		11
gate valve		13
generator room		13
glassmaker		11
go-between		11
gooseneck		12
gray		11
gridiron		11
grinding machine*		6
guncotton		12
hacksaw		12
half-hourly		11
half-nut		12
half-round		11
halftone		12
hallway		11

These words have not been approved by the Committee:

hammer-head*		4
hammer-wrought		11
hand-book		12
handhole		12
handmade		12
handwheel		12
handwork		11
hand-wrought		11
hard-drawn		11
headway		11
heat-treatment		12
heavy-duty		13
herringbone		11
high-potential		13
highroad		11
high-speed-tool steel		18
highway		11
hit-and-miss		11
hogback		11
hogchain		11
home-made		13
house-boat		11
hypotenuse	not hypothenuse	11
hysteresis		11
I-beam		19
ibidem	ib., ibid.	11
idem	id.	11
igniter		11
ignitible		11
imperial	imp.	14
incasing	not encasing	11
inch-pounds	in-lb.	14
inclosing	not enclosing	11
inclusive	inc.	14
indelible		11
india rubber		11
Indian Engineering Society	Ind. Eng. Soc.	14
inflater		11
infold	not enfold	11
input		13
insanitary		11
installing		11
instalment		11

These words have not been approved by the Committee:

Institution of Mechanical Engineers	Inst. M. E.	14
intake		13
intermediate gear*		2
intermediate-gear segment*		2
intermediate-gear stud*		2
intermediate-pressure	i-p.	14
internal-combustion		11
International Congress of Applied Chemistry	Int. Cong. Appl. Chem.	14
International Society for Testing Materials	Int. Soc. Test. Mat.	14
inverse hyperbolic sine of	$\sinh^{-1}$	14
ironclad		11
iron-mold		11
ironmonger		11
iron-ship builder		11
ironwork		11
ironworker		11
isothermal	isoth.	14
jackshaft		15
jack-screw		12
jam nut		11
jerry-built		11
journeyman		11
keyseat		12
keyway		12
kick-out		11
kiln-dry		11
kilos		11
landmark		11
lathe-bore		11
latticework		11
lay-by		11
lay-over		11
layshaft		17
leadscrew gear*		2
leather-working machinery*		6
leeway		11
left-hand		12
letter-perfect		11
levelman		11
lighted	not lit	11
limit	lim.	14

These words have not been approved by the Committee:

limekiln		11
limewater		11
line-drop voltmeter compensator		9
lineshaft		12
link-block		12
liquefy	not liquify	11
liter	not litre	11
loco citato (in the place cited)	loc. cit.	11
locomotive	loco.	14
locomotive engineer		13
logarithm	log.	14
long-distance		11
looker-on		11
lopsided		11
low-pressure*		4
low-priced*		4
low-speed*		4
lower feed-cone*		2
lukewarm		11
L (ell)		19
machinable		11
machine-made		11
machine rate		16
magnetos		11
make-and-break ignition		13
make-ready*		4
make-up*		4
management		16
mandrel		14
manhole		12
master plate		12
masterpiece		11
matter-of-fact		11
maximum	max.	14
mean horizontal candlepower	m.h.cp.	
mean lower hemispherical candlepower	m.l.h.cp.	
mean spherical candlepower	m.s.cp.	
metal drilling tools*		6
metal grinding tools*		6
metal turning tools*		6
metal-working machines*		6
millboard		11
milldam		11

These words have not been approved by the Committee:

millwright		11
miscellaneous	misc.	14
misfire		11
miter-box		12
modulus of elasticity in tension	E.	14
mold	not mould	11
moldboard		11
motor car		13
motorcyclist		11
motor-driven		11
mud drum		13
multi-phase		12
muzzle-loader		11
naphtha	not naptha	11
Napierian logarithm of	$\log_e$	14
natural	nat.	14
National District Heating Association	Nat. Dist. Htg. Assn.	14
network		13
nickel	not nickle	11
nickel-plated		13
nom-de-plume		12
northeast		12
number	N (math. tables)	14
oftentimes		12
oil-bath		12
oil groove		13
oilstone		12
O.K., O.K'd, O.K.ing		11
one-half		12
opere citato (works cited)	op. cit.	11
orebody		15
organization		16
ounces	oz.	14
outside diameter	O. D.	14
over-all		12
overflow		13
overhead		16
oxid	not oxide	11
pack-harden		12
passageway		13
patternmaker		12
peak load		13

These words have not been approved by the Committee:

penstock		13
perpendicular	perp.	14
phone		11
phosphor-bronze		12
pincers	not pinchers	11
pipe tongs		13
pipe wrench		13
pitman rods		11
pitmen	not pitmens	11
planning division		16
plow	not plough	11
pocketbook		12
point	pt.	14
polyphase		12
porcelain		11
premium		16
pressure gage		13
prick-punch		12
Proceedings	Proc.	14
program		11
pump room		13
punch-holder		12
puppet valve	not poppet valve	11
push-rod		12
quarts	qt.	14
quod vide (for which see)	q. v.	11
rack-cutter		12
radius	rad.	14
railway-accident		13
rainfall		13
rarefy	not rarify	11
rawhide		12
rectangular	rect.	14
reenforced	(again put into effect)	11
reengage	not re-engage	11
reeve	not reave	11
reexhaust		11
reinforced	construction work	11
resin		11
right-hand		12
rosin		11
rough-grind		12
rough-turn		12

These words have not been approved by the Committee:

roundhouse		12
routing		16
safety valve		13
sandblast		12
sandpaper		13
saturated	sat.	14
sawed	not sawn	11
sawing machine*	not saw	6
sawtooth		12
scheduling		16
scrap-book		12
screwdriven		12
sea-island cotton		11
secant of	sec	14
hyperbolic secant of	sech	14
inverse hyperbolic secant of	sech^{-1}	14
second-feet	sec.-ft.	11
segment	segm.	14
selvege	not selvedge	11
set-up		12
sewage	(matter)	11
sewerage	(structure)	11
shaping machine*		6
sheave	not shieve	11
sheet iron		13
shellac		11
shellacked		11
shipbuilding		12
shunt-wound		13
shut-down*		7
sine of	sin	14
hyperbolic sine of	sinh	14
single-hearth*		4
single-phase*		9
single-shear steel*		1
siphon	not syphon	11
six-cylinder		13
skee	not ski	11
skilful		11
slaked	not slacked	11
slide-rest		12
slide-rule		12

These words have not been approved by the Committee:

slotting machine*		6
smokebox		12
smolder	not smoulder	11
Society of Automobile Engineers	S. A. E.	14
someone		12
specific gravity	sp. gr.	11
speed-box		12
spillway		13
spindle thrust-bearing*		2
standard	std.	14
Standard (British) wire gage	S.W.G.	14
standpipe		13
steadyrest		12
steam chest		13
steamship		12
sternpost		12
stockholder		13
stone-working machinery*		6
stop-gage		12
stop-screw		12
store room		13
store-room		12
stove-lid		12
stuffing-box		12
sulfur		11
sulfureted		11
sulfureting		11
superheater		12
surface elevation		13
switchboard		12
swivel-plate		12
system		16
tail race		15
tailstock base*		2
tailstock body*		2
take-up*		7
tangent of	tan	14
arc whose tangent is	$\tan^{-1}$	14
hyperbolic tangent of	tanh	14
temperature	temp.	14
templet	not template	11
tensile strength	T. S.	14
three-phase*		9

These words have not been approved by the Committee:

three-ply		13
thrust-bearing check nuts*		2
thumb-screw		12
thumb-tack		12
tidewater		13
time element		16
time study		16
tool-dresser		12
tool-holder		12
toolmaker		12
tool-rest		12
tool-room		13
T-rail		19
Transactions	Trans.	14
triple-expansion*		4
T-slot		12
tubesheet		12
tumbler-gear latch*		2
tumbler-gear segment*		2
turning machine*		6
turntable		12
two-by-six rafters		13
two-cycle		13
two-phase		12
twyer	not tuyere	11
tying	not tieing	11
typewriter		
typist		
ultimate	ult.	14
unaflow		
una-flow		
under-cut		12
uni-directional-flow		
uniflow		
uni-flow		
United States Standard	U.S.S.	14
updraft		17
vaseline		11
velocity	vel.	14
Venturi tube		11
versed sine of	vers	14
versus	v.	11
versus	vs.	14

These words have not been approved by the Committee:

vertical	vert.	14
very-slow-speed motor		18
videlicet	viz.	11
vise		11
vitreous		11
vitrify	not vitrefy	11
voltmeter*		9
volume	vol.	14
volumetric	volum.	14
wash-room		12
water-jacketed		13
waterproof		12
watershed		13
water wheel		15
wedge-shaped		13
weight	wt.	14
wheel base		15
wheel-base		12
wheel-spindle		12
windmill		12
wire-drawing		13
wood-working machines*		6
wool-working machinery*		6
wood-worker		12
work-bench		12
work-shop		12
work-spindle		12
work-table		12
worm-gear		12
worm-wheel		12
wrist plate		15
wrought	wr't	14
wrought iron	W. I.	14
X ray		11
year(s)	yr.	14

Miscellaneous.

5/8-inch pipe	11
ten 10-horsepower cars	11
12-inch main	11
14 inches*	3
16-candlepower	13
35-candlepower lamp	11

75-horsepower engine 11

1. From the report of committee 24, on uniform nomenclature of iron and steel, International Association of Testing Materials, Eighth Congress, New York, 1913. (Not accepted.)
2. Preferred names for lathe parts as determined by a ballot of builders of lathes. See *American Machinist*, April 24, 1913.
3. From the report of a committee to co-operate in standardizing abbreviations, symbols, punctuation, etc., in technical papers. *Proceedings of the American Society of Civil Engineers*, April, 1904 (Volume XXX, No. 4), pp. 174–177.
4. Taken from an old style sheet of the American Society of Mechanical Engineers.
5. From C. B. Going, editor, *The Engineering Magazine.*
6. Suggested by Mr. D. M. Wright.
7. From a list prepared by W. P. Cutter, librarian of the Engineering Societies. 29 W. 39th Street, New York.
8. A. I. E. E. standard abbreviations and notation, edition of February, 1913.
9. From Standardization Rules of the American Institute of Electrical Engineers. Edition of December 1, 1914.
10. Suggested by Mr. W. W. Crosby.
11. From the Style Book, a compilation of rules governing executive, congressional, and departmental printing, Washington, D. C., 1913.
12. A list of words approved by the editor of *Machinery*, Mr. F. L. Rogers.
13. From an article by Professor C. W. Park in the November, 1915, number of the BULLETIN, S. P. E. E., on "The Writing of Compound Technical Terms."
14. From a list of abbreviations prepared by Professor Lionel S. Marks for his new handbook.
15. Suggested by Professor Wm. D. Ennis.
16. Suggested by Professor Hugo Diemer.
17. Suggested by Professor E. B. Norris.
18. From a list prepared by Mr. C. M. Sames.
19. Suggested by Mr. Chas. Day.

It is suggested that members of the Society who are interested write to the Public Printer, Washington, D. C., for a copy of the Style Book. This prescribes the forms, spellings, hyphenatings, and abbreviations that must be followed in Government publications. The Style Book itself recognizes Webster's New International Dictionary, edition of 1910, as an authority, from which it varies in certain specified cases. It is extremely likely that many of the forms given in the Style Book will be followed generally because of the fact that Government publication are often considered authoritative. There are some forms in the Style Book, however, that can be changed for the better in future editions.

The work connected with the preparation of this report has been too great to permit the consideration of uniform symbols for mechanics and hydraulics, as was suggested at the meeting of 1915.

Respectfully submitted,
John T. Faig, *Chairman,*
S. C. Earle,
W. D. Ennis,
F. N. Raymond,
D. M. Wright.

Discussion.

W. P. Cutter (by letter): In connection with the proposed issue of an Index to Technical Literature by the Library of the Engineering Societies, and the compilation of a Classification of Technical Literature to be used in conjunction with such an index, the question of nomenclature is of the greatest interest. For unless nomenclature of technical terms is standardized, uniformity in the classification and the index can not be assured.

Without attempting to discuss the report of the Committee on Technical Nomenclature in detail, which is impossible in the short time remaining I desire to call particular attention to the importance of adopting standard abbreviations to be used in citations of the titles of technical periodicals and society publications in indexes, footnotes, and bibliographies.

A rather hasty search made through the lists of abbreviations prefixed to several of the publications which index technical periodicals, reveals much lack of uniformity in practice. My object in calling attention to the need of reform in this particular is not to criticize the past action of technical bibliographers, but to indicate that, as uniformity is desirable for the purposes of the index above referred to, it may be well considered the duty and privilege of the Library of the Engineering Societies to prepare a suggested schedule of standard abbreviations for such words as Académie, Academy, Aëronautical, Allgemeine, American, Annalen, Annales, Annals, Année, Annuaire, Archief, Architectural, Archiv, Archives, Asociacion, Associacao, Association, Australasian, Automobile, and to all such generally used expressions as Bulletin, Transactions, Proceedings, Review, News, World, Age, Magazine, Record, Repertorium, Centralblatt, Zeitung, Zeitschrift.

The great importance of such a standardization as abbreviations will be recognized when it is stated that we have estimated that the number of entries required annually in a complete index to technical literature will be one hundred and fifty thousand, and the number of periodicals to be indexed is greater than one thousand. Were a standard list prepared, it would do much to correct the slipshod methods of making citations too common in technical literature. The preparation of such a list would involve no such differences of opinion as exist in the spelling, hyphenating and compounding of engineering terms, such as are given in the list published by the Committee.

The Library of the Engineering Societies has, as perhaps you are aware, published a Catalog of the Technical Periodicals in the Libraries of New York and vicinity, containing the description of over two thousand six hundred sets of periodicals and society publications devoted to technology, and the location of these sets in the libraries of the vicinity. Plans are now being perfected for the preparation of a similar list covering the important technical libraries of the United States and Canada. In conjunction with this latter list, it would be possible at slight additional cost to append to each entry the standard abbreviation for each periodical, for use by indexers, bibliographers, and authors and editors of engineering periodicals for citation of periodical literature.

These remarks are only suggestive as to what it is possible to do without much extra effort and at small expense.

Professor J. R. Benton: There is one small matter in which I think the Committee has made a mistake. I notice that among the abbreviations, those for the metrical units are given with a period, such as "cm." The International Congress of Weights and Measures have advised the use of these abbreviations without period. thus; "cm". This has been adopted in Europe, and it is also the usage of the technical periodicals published by the McGraw-Hill Publishing Company in this country.

One other remark. The Committee has placed too much stress, it seems to me, on what is merely customary rather than on what is inherently desirable. It has taken a great deal of pains to ascertain present usages. That is just what the dictionary makers used to do, and it resulted in giving us our abominable and illogical English orthography. If the Committee could see its way to get away from that method, and not, as the Chiarman has said, avoid "putting anything over on anybody," but instead go right ahead and "put things over" on us, doing what it thinks logical instead of merely customary I think it would get better results. For my part, I am quite willing to be governed by its recommendations, regardless of my past habits; and I think most of us would feel the same way.

Professor D. C. Jackson: The man who should determine this is not the man who has only experience in the professional engineering work and who has not studied the effect of such writings on others who are less expert than himself; but it should be determined in the way phraseology affects others. who are not expert in the art within which the writing belongs.

Professor J. T. Faig: Here is the word "constant-potential transformer," with the hyphen between "constant" and "potential." There are lots of men who object to putting the hyphen in.

Professor Jackson: There is a device which is a "potential transformer." That is a compound noun. There is also a device which is a ''constant-potential transformer,'' ''transformer'' being the noun and ''constant-potential'' the adjective element. To avoid the latter being ambiguous, the hyphen is put between ''constant'' and ''potential.'' To put the hyphen between ''potential'' and ''transformer'' is also often desirable when ''potential-transformer'' is a compound.

Professor Faig: Many engineers want the hyphens out.

Professor Jackson: The experienced electrical engineer will understand the thing by the context. He, therefore, does not need the hyphens. But he is not a competent judge of the needs of the textbooks. The latter judge must be a man who can recognize the effect of the language of the inexpert reader. That man will put the hyphens where they are needed, so the thing will not be ambiguous.

Professor Faig: Would you always put the hyphen in adjective modifiers?

Professor Jackson: Not always, but generally. I have come to this after struggles with proof-readers who obviously did not get my meaning, and I have found that others have had the same difficulty.

Professor J. S. Lapham: I notice in the provisional list the spelling of ''chlorin'' without the final ''e.'' I think this is in accord with the best non-technical usage, that it indicates the correct pronunciation of the word, and ought to be adopted. I see that ''gasoline'' is not included at all. I would suggest that the list include ''gasoline'' and that it be spelled ''ene'' and not ''ine.'' This corresponds with the spelling of ''kerosene,'' and indicates the popular pronunciation of the word. I realize that this is against the authority of the American Society for Testing Materials, who give it in their list and spell it ''gasoline''; but it will always be pronounced ''gasolene'' and there is an increasing tendency to spell it in that way. It has no proper etymology, anyway. It would then fall in line with kerosene, which so far as I know has always been spelled ''ene.'' ''Benzine'' is a special word. I think it is in the provisional list without the final ''e.'' It is a good idea to make that change, to have it correspond with chlorin, chlorid, etc. The coal tar product should be spelled "benzene."

Professor C. W. Park: I have already said a number of things about the theory of compounds, so that I shall pass over that unless the question is raised, and simply discuss it from the standpoint of a teacher of English. It may not be so serious a matter to others whether the hyphen is put in or left out. But the teacher of English, if he is conscientious, when he is asked which is the better form, will endeavor to tell his students; in the first place, because they like to write consistently if they have a chance, and in the second place, because it is the best possible thing for the student to get a positive attitude toward a word. If his mind is constantly wavering between possible forms, the whole tone of his writing is certain to be influenced. He will be less direct and will not write in a clean-cut style.

I want to give you, if I may use the blackboard just a minute, an illustration which I think goes even farther than any of those Professor Faig cited. A short time ago I had a letter from an editor of a technical publication, asking, "What are you going to do about this expression, which is stated in all these ways:

¾ inch
¾ inches
¾ of an inch
0.75 inch
0.75 inches
0.75 of an inch
three-fourths inch
three-quarters inch, and so on,
not to mention ¾″?

I was especially interested, because the same question had been put to me by my students. They asked, "What are we going to do about this kind of expression?" I do not feel that in all of these cases, and perhaps not in many of them, instructors in English should be the final arbiters; but I do believe that a certain amount of standardization should be required in cases of this kind. We have a right to insist that our students have the privilege of writing something that they may be sure is the authorized form.

It seems to me that in the case of technical expressions such as we have had occasion to discuss this morning, there is the best possible opportunity to get standardization. These terms are specific; they are definite in meaning. They are used among a comparatively small number of men; in fact, they are coined, adopted, and used by the same general group of men. It seems to me that if these men can agree upon certain mathematical symbols, which they all do agree upon, they can or should agree upon clear, definite technical expressions, such as we have had occasion to consider here. My plea is that the Committee be supported by every one in its effort to bring about this standardization, and that this support should be given in the interest of the engineering students of the country, who need all the help they can get in English, as the report of our Committee No. 12 will show.

To repeat just this one idea. It may seem a very small matter to any one whether any of these expressions are written thus and so. It is only a part of the mechanics of expression, as we have come to regard it. But viewed even from that standpoint, it is very important that the student who is getting his bearings, who is learning to write, shall be able to use as many of these terms as possible in a perfectly consistent way. We attempt to get at that in the University of Cincinnati by securing agreement among all the professors of technical subjects as to the form of technical reports; and it has been in connection with this effort at standardization that we have threshed out a great deal of the material which Professor Faig has referred to in his report.

Professor W. T. Magruder: It looks as if the Committee on Technical Nomenclature had a magnificent opportunity to take the leadership in this matter and to do a fine piece of work for the engineering profession. Many of us are members of one or more national engineering societies, and as such have some slight influence in those societies. All of us have some influence in this Society. It would seem that this Society has a duty to perform in getting the national engineering societies to appoint a joint committee to work on the revision of the whole subject of technical and engineering nomenclature.

A bit of history may be of interest here. The need for our Committee was suggested by Mr. D. M. Wright, who got into trouble with the United States Treasury Department as to the question of whether an assembled collection of metal parts was a machine or a machine-tool. For example, is an engine-lathe a machine or a machine-tool? If it is the one, then the customs-duty was so much per cent.; while if it is the other, then it was a different per cent.; and so this is a financial question of some importance to engineers and a cause of worriment as to whether it goes by one name or the other.

In my judgment, this Committee has not yet touched upon the most vital part of the whole subject—namely, the question, not of orthography or of orthoepy, but the question of lexicography. I commend that particular aspect of the subject to the Committee.

They have divided the subject into two parts, dealing with orthography and orthoepy. I do not believe it becomes this Society to correct misspellings. If a man does not know how to spell a name, he should learn how. If you think that "Beaumé" is a *beautiful* name, go ahead, but do not count yourself as being an educated engineer, because Baumé did not spell his name that way. There are many mistakes of that kind in orthography which this Society should not condescend to consider.

This committee and this Society should be progressive in this matter. The report is not progressive enough, at least to suit the speaker. The chairman states that a certain change cannot be made unless it is approved by the dictionary. The dictionary only follows where we lead. The dictionary says that we must say *cem*ent, but we engineers do not say *cem*ent, and to do so would be pedantic. The engineer, the maker, and the user of the article have called it ce*ment* for many years and will probably continue to do so. That is orthoepy.

I am opposed to the first rule for compound technical terms, namely, "Omit hyphens with compound nouns," and with "railroad" as the example. I think it is well for us to go ahead, be progressive, take the leadership in this matter, and write words in the way that seems logical and that educated people who use the word think that it should be written. We will always be in a transitional state with respect to some words. The time was when we used to have black smiths in distinction from white smiths; then we had blacksmiths and whitesmiths; today, we seldom hear of whitesmiths, but only of blacksmiths and tinsmiths. That is lexicography.

The report says: "Do not write a compound noun as one word unless it is so given generally in the dictionaries." This principle is almost immoral, neither is it progressive. Let us take the leadership in this matter. Compound it and call it a word. If you want to use railroad and boilerroom each as one word, do so. We are gradually working in that direction and can not be held back. Let us use these words in this way because they represent one single thing. Boilerroom represents one thing. When you think of a boilerroom, you do not think of a boiler and then of a room, any more than you think of the rails and then of the roadbed on which they were laid. You think of the boilerroom collectively as a place.

The committee desires us to make exceptions when a compound term is a simple scientific unit. Yes; but what about commercial units? Why not let them follow and be treated similarly?

I am opposed to the orthography of a number of the words in the report, and in particular to "crank pin." I would like to see it always used as one word—crankpin, and not crank-pin or crank pin. It is no longer a cranked pin, except in rare cases. A cast steel-gear is quite a different article from a cast-steel gear; and a cast steel gear might be either. And so of many others.

The particular thing that hurts my Americanism is that the "Standard Wire Gauge" must be British, and that therefore our United States and American Gauges can not be accepted as "Standards." I am not hyphenated enough for that!

It is to be noted that the Style Book of the Government Printing Office recommends the use of "puppet valve," rather than "poppet valve." I understand that the name "puppet valve" was suggested by the old Punch-and-Judy and other puppet shows. One can readily see how when these valves flew up, they gave some one the idea of a puppet show. The term poppet has better philology to commend it. If we are to accept the term *pup*pet valve, I would suggest that we be consistent and speak of a "pup" safety valve. Let us have more lexicography and consistency.

Professor Jackson: I think the exceptions under rule one are not properly described. The rule says: "Omit hyphens with compound nouns." The exception says: "When a compound noun is composed of two or more words, each of which is a distinct engineering unit." The examples in that case are not what the statement would lead you to expect them to be; they are, in fact, abbreviations. Kilowatt-hour means one kilowatt used for one hour; and ton-mile means a ton hauled one mile. The hyphen in these two instances is for the purpose of indicating the abbreviation, not for the purpose of indicating kilowatt as one unit and hour as another. I think I am right in that interpretation of the exceptions, and I would suggest that perhaps section *b* might be applied to abbreviations, and then kilowatt-hour and ton-mile would be appropriate.

Professor Faig: Do I understand that you are objecting to the use of the hyphen?

Professor Jackson: Not to the use of the hyphen, but to the implication that it is there because "kilowatt" and "hour" are separate units. The actual fact is that it is an abbreviation. The hyphen stands for "per."

Professor Faig: How about foot-pound?

Professor Jackson: That is another proposition, although it might be brought under this particular rule. It would be nearer to an example of your exception than the others you give. Why say constant-speed, but direct current? Why say counter clockwise convention; then say counter-electromotive force? In other words, why not say counter-clockwise if you are going to say counter-electromotive? There is as much reason for the use of the hyphen in the one place as there is in the other. Why say high-duty and high-speed with the hyphen, and not high pressure? Let us be consistent, as far as we can. If we are going to get the recommendations of such a report into general use by text-book writers, we must be at least somewhat consistent.

Professor Park: I am quite willing to leave all the questions of interpretation of terms to the excellent authorities we have already heard this evening. I suppose if, when I began to teach engineering English, I had been asked to explain what a traveling crane was, I should have said that a traveling crane was a migratory aquatic bird; and that is about as near as I can hope to come to the definition of some highly technical terms. But from the standpoint of the laws of English, I think there may be something to be said; and I believe that, consciously or not, we have been working toward the recognition of certain sound principles. I noticed when the first speaker was using some compound expressions this evening, he indicated by his accent the difference he felt between an expression which was a compound and one which was not. That is one of the best tests possible, and I think it may help us a good deal in distinguishing what is a legitimate and actual compound from what is a spurious compound.

A friend of mine furnishes me with an illustration of this rule. He was going out of Boston with a party on a suburban line to a house which no one in the group had ever visited. According to their instructions, they were to take the car, and go till they came to a green house, or a greenhouse. The lady who told them this spoke in a very level tone, so the party was about equally divided between a greenhouse and a green house. As is usual in cases where there are two possibilities, they chose the wrong one, rode for a mile or two past the greenhouse, their proper destination, all because the lady had not recognized with sufficient care a very important principle in the compounding of words—namely, that the accent falls upon the first, or descriptive, part of a compound noun.

Now, I suppose that the first time the expression "internal combustion" was used, it was probably in a simple connection; but when it came to be used to describe a particular kind of motor, an internal-combustion motor, the tendency was so clearly felt by the person who wrote it that he probably distinguished it either by putting the words in quotation marks or by connecting them with a hyphen, which is another method of accomplishing the same result. But that created a compound adjective expression, *internal-combustion,* which of course has become a technical term.

While we are on the subject, and are discussing it from the standpoint of English, I would like to point out—and I do not want to be invidious in this at all—a tendency that is largely manifest in technical writing and somewhat in other writing, to form these compounds loosely, often without regard to whether or not they are technical expressions. For instance, I found this expression in a discussion of the Ford motor plant. The writer said something like this: "The car cost-reduction and the car selling-system efficiency have combined to produce an unparalleled car-sales volume." Now, you notice what that writer was doing. He was yielding to the temptation to form compounds indiscriminately. But what he was creating was not technical compounds, but a series of what I should call "prepositionless phrases." Instead of "reduction of costs," for instance, he said "cost-reduction," and so on. These are spurious and illegitimate compounds which I think should be carefully considered in connection with any general discussion of compounds; and that tendency in style should be counteracted. By avoiding these awkward expressions, we shall give real technical compounds the distinction which they deserve.

I have spoken of the accent test as one important feature.

That is the test which is most conveniently applied of all. Another test would be that of meaning. Do we really mean to use a term in a technical sense? Or are we just using it carelessly, by analogy with the numerous compound expressions we find in a technical style?

I want to say that I believe that, whether consciously or not, in your publications—your technical journals and other writings—your writers and editors are tending toward a simplification that rests upon logic and common sense; and I believe in the long run that it will be found that usage in language does rest upon these principles. If you recall the numerous examples I had on the board this morning, of the way of stating ''three-fourths''—and I might have added to the list $\frac{3}{4}$ in.—you remember the permutations and combinations which were possible. The best opinion I can get, gathering it from technical men, is that usage tends to crystallize about some such expression as $\frac{3}{4}$ inch. ''Three-quarters of an inch'' or ''three-fourths of an inch,'' written in full, are ruled out because they look approximate instead of accurate, and look bulky instead of simplified and concise. Technical language, of course, tends toward conciseness of expression. The decimals were ruled out, as technical men have explained to me, because they prefer to keep the decimals to express small and more minute and accurate expressions. If they said two hundred and thirty-seven one-thousandths, they would prefer to state it in decimals; but three-fourths is preferred in the form of the common fraction. These are instances in which, consciously or not, technical men in their own usage tend, I think, generally to arrive at logical and common sense solutions for most of these questions.

Despite the confusion we have all seen in this matter, I must say that I for one feel very much encouraged when I note the prevailing tendency toward these simplified and common sense expressions. I believe that what this Society is trying to do—that is, to get a conscious reaction from the different members on questions of this kind—is simply going to hasten processes that by the evolution of language are already on their way, and to obtain for us sooner, therefore, the standardized forms that we very much need.

As was pointed out this morning, if the student finds that it does not matter much which way he writes a thing, he will come to the conclusion that this applies not only to certain expressions, but to everything; and he will become slipshod and careless in the use of the language, because this will seem an invitation to inaccuracy and inconsistency. I think that is the strongest reason why this organization should assist in hastening these normal processes of standardization in the use of technical terms.

Mr. Harry Barker: As an editor, perhaps I might say a word. I should like to endorse the stand taken by Professor Kent this morning. We are driven to that. We intentionally hyphenate rather than, as the Committee says, eliminate the hyphens; and there is no need of explaining this position any more than the professor did this morning. What he said is the attitude of the editors of practically all the engineering publications in the country. They are driven to it in order to express clearly and unmistakably the sense of what they want to say.

In the matter of the list of hyphenated and questionable terms, I think there is a great field for this Committee to start a good work. Every editorial staff has to have some standardization within its own organization. Unless there is, the paper gets to be the most surprising assemblage of English you can imagine. No two pages would be consistent; no two editors would work alike in the matter of abbreviations and hyphenizations and compound words. We do not care particularly what rule we follow, so long as it allows us to express unmistakably the meaning we want to convey; and so long as it is a standard that is recognized by everybody in the organization. The different papers are probably willing to accept a universal standard if it meets that one criterion of expressing the meaning unmistakably.

Coming to the list itself, as given here, occasionally something peculiar crops out. It must be expected, of course, that such things will creep into any list. Any list will have to be revised, probably every four or five years, in order to keep up with advanced practise.

Professor Magruder: I should like to second Professor Faig's motion which he made this morning that the Committee on Technical Nomenclature take up this question with the national engineering societies, looking to the appointment of a joint committee of two members from each of these societies to act as joint committee on the subject of engineering nomenclature, and to amend it by adding that this motion be referred to the Council with the recommendation of the Convention that it be authorized. We have precedent, if such is necessary, for this action in the appointment of the joint Committee on Engineering Education. (The motion was carried.)

Professor A. M. Greene: Before closing the subject, I should like to suggest that the Committee also endeavor to include in this report some standardization of symbols. In some books on thermodynamics I still find r used for the heat of vaporization, and in other books h or l is used for the same thing. If we take up the matter of hydraulic turbine design, we will find *that one author uses* v_1 v_2 *and* v_3 *for certain velocities*, while another will use c, u and w. If the Committee could only standardize these for us, or suggest a set of symbols for work in applied mathematics, I think it would be of great assistance to the student body of the country, and it would aid some of the authors, also. I think this should go to the Committee on Abbreviations and Nomenclature.

Professor H. S. Jacoby: You do not mean to imply that the work on nomenclature should necessarily include symbols?

Professor Greene: No, not necessarily; but I think this should be submitted to the Committee. I feel that they have done this other work very well, and they would be able to handle the additional burden satisfactorily.

Professor Faig: The gentleman who preceded me has stated the rules very well; and we are in favor of them, except possibly the last one. This report represents, as I have said, not my views, but the views of the members of the Society so far as we could ascertain them. In the degree in which this report does not satisfy the membership, in just that degree the Committee has failed to get an accurate expression of opinion from the members. We will all have an opportunity to correct it when the report is taken up again.

I would like to have a vote of those present as to the matter of hyphenating such compound modifiers as "constant-potential" in the expression "constant-potential transformers." Of these we are not sure, because the data obtained from members of the Society is conflicting. Those who are in favor of hyphenating compound adjective modifiers as illustrated by the expression "constant-potential transformers" are asked to raise their hands.

(Carried by unanimous vote.)

I did not get here in time to hear the beginning of Professor Magruder's remarks. Certain suggestions for change in the names of machine tools were made by Mr. Wright, and put on the list the same as the other words were. There was practicaly nothing handed in on that. No one seemed to care to change the expression "lathe" to "horizontal turning machine." I was unable to get many suggestions from manufacturers of machine tools, probably because they have been extremely busy during the past two years.

The term "crank pin" has been in use for more than one hundred years and yet it has remained to most people "crank pin." A committee of the American Society of Mechanical Engineers presented a report on technical terms some years ago. They saw fit to write "crank pin" as two words without the hyphen. We should not change a term upon which there is substantial agreement. As soon as we find that a majority are in favor of "crankpin" as one word, we will recommend that form.

At the beginning we hoped for consistency. That is behind us. If we can get one way of writing each word, so that it will be acceptable, we shall be delighted. That is all we hope for. I could speak quite convincingly on the other side of the argument, because I am rather more conscious of the vulnerability of this report than any one else can be.

I should like to call attention to the style book of the public printer. All the bulletins of the United States government have to conform to the forms of the style book. That gives them a sort of authority. A few weeks ago another society had the daring and progressiveness to recommend forms which our Committee had not the temerity to present. Some of these forms are directly contrary to the style books of the public printer, contrary to every publication of the United States government, and also contrary to established custom in this country and abroad. There is no doubt in the world that these will not be followed. It is easy to get up a set of rules. It is a different thing to secure general acceptance of the rules. I believe firmly that the tendencies shown by the rules in this report really exist. I think the general tendency is toward simplification by elimination of the hyphen.

RESEARCH AS AN ELEMENT OF THE GROWTH AND PROGRESS OF THE SCHOOL.

BY P. F. WALKER,

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As developed in the minds of those who were determining the form of the discussion to be held at this time, the topic was divided among the following sub-heads:

(*a*) Research as a direct aid to teaching.
(*b*) Research as a means to keep instructors in condition of growth.
(*c*) Research for the intrinsic value of results.
(*d*) Research to make possible the efficient and economic utilization of laboratory equipment.
(*e*) What the institution should do in the matter.

It is the thought of the writer that when the above topic and outline has been set down, the opening paper for its presentation to the membership of the Society is fully written. Nothing more is truly necessary. The benefit to be derived will come from discussion by the many rather than by one or two, and it is proposed to make this opening discussion simply one among those which are expected to follow.

It is evident, of course, that we are considering the research possibilities and research functions of the school. As school men and would-be educators it is incumbent upon us to consider the ultimate purpose of the school and the means which contribute most effectively to the accomplishment of the ultimate purpose. Important as research is when viewed in the light of results in the advancement of knowledge and of the arts, the main purpose of the school is to teach. The strongest men obtainable are needed there and, once secured, the first concern of the institution should be to fix the conditions under which they may labor effectively and consistently. To be strong they must be growing men. It may be taken as axiomatic that that policy of administration which fails to include in its program the fostering of those factors which minister to the growth of the teaching staff, is providing for a period of stagnation and decay. It may be that the conditions which make for growth and development for the one man will be impotent in the case of another, so there is no disposition at this time to argue for the commonly accepted forms of research topics and methods as a panacea for all ills; no intention of saying that every man on our engineering faculties must engage in formalized research along some technical line within his field. But at this time it is maintained that research is one of the elements which contributes to the desired result. If it be granted that many of our men in faculty positions are capable of directing and conducting investigations along technical lines, then the question is confessedly not an academic one but one which bears upon both school and industrial work in a very direct and special manner.

The four leading sub-heads listed above indicate the principal purposes for research in our established schools. The man who is meeting live students and discussing topics of engineering character which must be live themselves, has no easy task cut out for him, if he is to command the interest of all. Every condition and circumstance which lends interest and vitality is a distinct help. It is not enough that the instructor should read his magazines and keep up on current topics and other accomplishments in the field. Knowledge of his subject and all of the many personal characteristics of which we hear so much these days are necessary, each and every one, so that none may be omitted. A vital element in the process of teaching, however, is the attitude of the student which reflects in many ways the condition of mind of the instructor himself. The creation of interest and enthusiasm depends upon the extent to which the same elements are present in the teaching, and in the great majority of cases the possession of these calls for active participation in the advancement of the subject. In addition to these unconscious influences which pass between instructor and student there is a positive factor present in the shape of the conscious recognition on the part of the student of the progressive spirit which impells his instructor to participate in progressive work. He knows, and gives full credit for it, that the man to whom he is looking for guidance and assistance is himself so thoroughly a master in his branch that work which the latter is doing is recognized abroad as well as at home. The double purpose indicated by the first two of the main topics is thus met in the case of those men who are so constituted that they are successful in research. The great majority of our faculty men are in this class.

A common fault, not peculiar to teachers of engineering but one to which all who think upon matters of scientific and industrial significance are liable, is the error of assumption of the infallibility of scientifically expressed results. The tendency to accept statements which are made by science workers as though these workers possessed some unusual and distinctive insight, is strong. People have generally seemed to feel that anyone who spoke in scientific terms and handled natural elements through the medium of scientific apparatus must of necessity have some special hold on a power to interpret the secrets of nature by processes which differed in some unexplainable way from methods employed by others who proceeded along other paths of reasoning.

As a matter of fact the history of the development of science is marked by the succeeding steps which the devoted workers have succeeded in taking. Thus in the realms of heat or light or electricity, theory after theory has been evolved, lived through its short day, and then passed on to be succeeded by the next member of the series. Each in its turn was entitled to respect because it seemed to explain the facts of life which were at the time foremost in the minds of the workers, and the man who has kept abreast of the situation is one who has taken these explanations at their face value and with a consciousness of possible limitations. It is only by the exercise of this spirit that we progress at all along lines of science or along lines of practical adaptation of scientific principles to industry.

The non-progressive man is the one who fails to catch the spirit which animates true research and this he does by reason of his mind being unoccupied with the world of cause and effect. His mind is remaining at rest on the established principles enumerated in his text-book and the end for him is at the beginning. A writer in a recent number of *Science* touches this point in these words:

"The only preventive force is the scientific spirit. It is a development of the quality or tendency of the mind which has compelled man in all the periods of his history to discard or to recast his truths because they do not work, and to accept new ones because they do work. That tendency in common life has operated crudely and slowly, it has caused countless mistakes and the temporary acceptance of countless errors, but it has brought us to our present stage of civilization. It is indeed nothing else than the pragmatic spirit. The scientific spirit is the pragmatic spirit trained in the strictest fashion to accept only what answers rigid tests and reinforced by an intense curiosity or desire to know. The very essence of this spirit is manifested in the habit of unceasing, relentless criticism. Without such incessant criticism there would be chaos in science. The scientific spirit, as thus understood, is an all-powerful factor in establishing scientific truth."

The man who is really imbued with this spirit goes before his class with an enthusiasm that is born of a fire which cannot be quenched. He works because he loves to work and the students who sit before him recognize that fact with an accuracy that is as keen and appreciative of power as it is deadly in detecting the formality of the copyist. Such a man is a teacher in the truest sense of the term and if he is produced once in a decade by the expenditure of whatever is necessary in order to provide him with the means for the exercise of his active mind, the expenditure is warranted a thousand times over. That research can do this, and that for many men it is the only agency through which expression of force and genius is possible, is a fact so well known that it need not be repeated.

There is little necessity to enlarge here upon the intrinsic value of that which is accomplished through the medium of the laboratory. Before the people of the country at large, however, there may be reason for such an argument. Another writer has this to say at this point, while addressing a recent gathering:

"I want you to realize that in America we are going ahead in the future at a rate dependent entirely upon our preparation. Laboratories are a relatively modern thing. In most of the sciences they are a development within the lives of men now living. I want you to see that we must be foremost in systematic, organized research, or we will be distanced by other countries which already well recognize the value of new knowledge.

"When so much of our material welfare, the condition and extent of our manufactures, the quality of our agricultural efforts, and the health of our people, depend upon the rate of our acquirement of new knowledge, there ought to be much greater effort made along the lines of research than is at present the case."

To accomplish all this there are two well-recognized methods of procedure. The one is to employ for the work, associating them with laboratories, which, we may say, are employed for school work, men whose only duty it is to engage in lines of investigation. The other method is that of carrying it on through men who come daily into contact with students in the class room, freeing them from drudgery so as to make possible the application of their time and energy to the desired results. From what has proceeded it is not difficult to conclude that in the mind of the writer nearly every argument turns in favor of the latter procedure. Under appropriate conditions which are readily realized, results of full value are procurable and at the same time there will be possible that other development which is so essential to the efficient teacher. Too often the question is argued and decided upon the basis of the one element of financial efficiency in results and thereby a most vivid example given of reasoning by methods which are the reverse of scientific. To arrive at the true conclusion every advantage and every item in the stream of results which flow from such a source must be considered. Here, as in other lines of science, the administrator and the student of educational policies must possess the spirit of willingness to accept principles if they work and to discount them if they do not work. There is no lack of instances to show that the opening up of opportunities for the exercise of the creative spirit and genius of the teacher has resulted in a total effect which embodied the double result just indicated. Important investigational results have been accomplished by men whose lives have been devoted to the cause of education and who have become great teachers through their work.

After all, there may arise the question of what is research and what may be the other classes of activity which will bring the opportunity and the results to those who may not be adapted to research of our stereotyped forms. For some it is investigation in its purest meaning. For others it is the opportunity for participation in the active affairs of industry, be it construction, public utilities service, or what not. For some it may be that intensive devotion to study and service which results in the writing of books. A well-known publisher, but recently deceased, is credited with a remark that no college professor is satisfied until he has written at least one book. May it not be true that such a condition is the result of the limitations which have been cast about so many educators and which have compelled them to find an outlet for their energies by doing that one thing for which so many are unfitted? May not the genuine be attained if conditions are such that those who may best investigate, investigate; that those who best may practice their profession in the community industrialism, so participate; and that those who best may write, write books?

Have administrators of institutions devoted to science exercised the scientific spirit in deciding these problems, is a fair question. It may be assumed that schools of this type touch the industrial life of the region. This is particularly the opportunity for those connected with the publicly supported schools, such as our state universities. For such, the question of results measured in terms of commerce and industry is a pressing question, but no less pressing is that other one of the need of effective handling of the human stream of student life which flows past him. No less real, let us add, is the justice of the idea that it is a matter of concern for school executives to recognize the good of that other less rapidly flowing stream of instructors, the workers on which the real burden falls. In the main these administrators are of scientific and technical training, and by them should the strict analysis of all influencing conditions be made. In this, no more than in the other affairs which make up the busy life of the world, should we expect that the one conclusion will hold for all, but in many cases it is evident that the true conclusion will be that research performs its greatest function, and makes possible the most complete utilization of available equipment, when it is being adjusted to meet the needs, and furnishes the outlet for the ambitions, of the men who are moulding the lives of students by daily contact in the class rooms.

Discussion.

Professor D. C. Jackson: The chairman gives me great credit for carrying on research. I want to say that I am not the one in the electrical engineering department of the Massachusetts Institute of Technology who has the best opportunity to do research. If I did not have other things to do, I should rejoice to take charge of the research in that department, but there are other things which I have to do. There is another man in our department who is very deeply interested in and particularly gifted for carrying on research, so we compromise by giving him the immediate supervision of that work.

I express my opinion of the desirability of research, however, from considerable experience. Even in the days when the department of electrical engineering at the University of Wisconsin was small, we were all doing some minor work of advanced character with advanced students; and most of us were doing some work that was at least extending our own knowledge, if not the knowledge of the world. When, several years ago, I had the good fortune to go to the Massachusetts Institute of Technology, it was with the understanding of all concerned that I was an exponent of the advantages of carrying on advanced study and research in an engineering department as a matter of aiding undergraduate work, as well as of being serviceable in other ways. We have been so fortunate, under the circumstances there, as to have a great deal of sympathy and support for our work.

I agree with Dean Walker that there are four important matters to consider in viewing the effect of research. He names them under heads *a*, *b*, *c*, and *d*. I do not care much about the last. We use our student laboratory equipment just as much as we can, but the first purpose is to make good use for teaching purposes, as we have, and to get the proper educational effect. Consequently, I do not dwell particularly upon research as a means to make the most economical use of student laboratory equipment. If that were the only subject, research probably would not be important to us. But from the standpoint of the influence on teaching—which I presume is meant by Dean Walker to refer more particularly to the influence upon the undergraduate students themselves, which influence is gained through the effect of the teaching—from that standpoint the introduction of a considerable amount of advanced research in a department is well worthy of careful consideration.

It is also worthy of consideration because of the influence upon the instructors. Dean Walker is entirely too modest. I had some correspondence with him about his paper, and he expressed the opinion that the real benefit in the presentation here would come from the discussion which might be aroused by the outline which he would lay down.

He also is too modest in the way he presents the status of this Society as a society of educators. He calls them "would-be educators." We will have to admit that we are schoolmen, and I think we ought to assume that we are educators. If we are not, it is time to find out why not, and take steps to become so. I, therefore, do not like such extreme modesty.

I will now turn to the way in which research is carried on in the electrical department of the Massachusetts Institute of Technology. Research is carried on in other departments of that engineering school, and in many other schools; but being close to this, and knowing more about it, I confine my remarks to the one department of that Institution.

After considering the matter carefully, we decided—and this thing was all talked over carefully by the department staff—to carry on formal research in the department as a part of our activities. It was opposed at that time by some of our men, but I am happy to say that men who were reluctant then are now quite enthusiastic over the results of our work.

After considering the matter carefully, we decided that as a teaching staff we were busy, and we would not have time to actually do the kind and amount of work we desired to do in research, if we ourselves tried to do it without being aided by research assistants. We, therefore, succeeded in obtaining an appropriation which enabled us to employ research assistants. Having attained that point, we came to the conclusion that if we were to have several research assistants and were not to waste time and money, one man on the staff would have to be substantially responsible for seeing that these men were kept busy. We, therefore, made what we call a research division in the electrical engineering department and appointed one of our men director of that division. Each man in the faculty who wishes such an assignment has one or more research assistants under his immediate direction. Professor Kennelly was appointed director of research, and he was relieved of all his teaching except one postgraduate course running through the year, and one undergraduate course running for a half year.

Our postgraduate students have increased rapidly in numbers. We have from four to six or eight master's theses going on each year, and one or two doctor's theses each year. The consequence is that our postgraduate students do a good deal of research work all the time. Our senior students come constantly in contact with this work and our juniors more or less, because we plan to keep undergraduate and postgraduate work together as much as possible. We constantly get results from the research which we can utilize in the classroom. For instance, take the case of alternating-current power transmission in which the problem of the distribution of current over the cross-section of a conductor is of importance. That is a problem which has been solved mathematically for cylindrical wires, but the mathematical solution had never been checked by thoroughgoing experiments; and while everybody was more or less satisfied with it, still there was no demonstration of its accuracy. We started a research assistant to work on that problem, and after checking the accuracy of the formula for cylindrical wires, we have produced a formula for flat strips. These things we pass on to our students in the classroom and the students look upon the work of the department as live work, which is certainly of moment to them. I could multiply the illustrations, but stop at the one, only adding that the results of our researches are proving serviceable in the industries.

The attitude of mind resulting from this work has also in my opinion, had a large influence for good on the teaching itself. I think it is fair to say that this is a fairly assured reaction of research when properly carried on. I think in one of his subdivisions Dean Walker refers explicitly to that effect, as well as to the effect on the students. Experience plainly shows the admirable influence of properly supervised research on both the teachers and the taught, and it is my opinion that no engineering school should fail to encourage its staff to do such research work as they are capable of doing. But it must be remembered that research work requires concentration on its problems, like that required in teaching, and it is not enough different from teaching to make it recreation, so that teachers who supervise or carry on research must be relieved of some of their standard hours of teaching.

Professor C. L. Crandall: In the civil engineering college at Cornell, research has been of fairly recent growth. At least. in the early days of the university there was no encouragement in that direction on the part of the authorities. Later on an appropriation was secured for a laboratory building. After the building was completed we were told that no money whatever would be available for anything except teaching. It was then five or six years before we could get any equipment.

This has been remedied, and at present quite a little work is going on in the way of investigation. Professor Mills has charge of the testing materials laboratory, and he has considerable time available outside of that required for teaching. In the hydraulic laboratory, quite a good many contributions have been made to the science of hydraulics. Outside work has come in and a good deal has been done along the line of investigation both by students and the regular instructing force.

At Sibley College of Mechanical Engineering a department of research was organized several years ago and a larger force has been available for the work than in civil engineering.

To quite an extent, the students, seniors and graduate students, have come in contact with the research work directly. In other cases they come in contact indirectly, and they get a good deal of inspiration from that portion of the work. Taking the broad definition which Professor Walker has given, we are able from time to time to bring students in contact with questions in actual practise, which prove of very great interest to them, and furnish an element of inspiration for the entire class.

I do not know that I can say much more. The subject of investigation has been discussed during all the meetings of the Society for the entire week, and I think every one appreciates the advantages. The subject of research is one which is rather indefinite in the minds of many people. When the Society of the Sigma Xi was first organized, ten per cent. of our graduating classes could be elected to membership. After a few years it was realized that this was a mistake, and practically no one was elected from the senior class as meeting the requirements. The subject of research as it is now interpreted for seniors involves ability to do original work as evidenced by some foresight and skill in taking a problem and working it through with only general directions; and on that basis those who meet the requirements are in a stage of development which shows better promise of their becoming engineers than the rank and file of the class.

Professor H. F. Moore: In the discussion of the desirability of research work by engineering teachers the speaker desires to comment on the apparent antithesis, noted by Dean Walker, between two methods of doing research work—one, by employing special research men, and the other, by utilizing the teaching staff. At the University of Illinois the employment of special research men has not been found to inhibit research work by the instructional staff; in fact, a good degree of coöperation and mutual interest between the research staff and the teaching staff has resulted. I think I can show this better by two illustrations than by a formal statement.

One piece of special research work financed and organized outside the teaching staff is a research on stresses in railroad track and ballast. For this work there was organized a special paid party of workers. A member of the instructional staff, who was making investigations on the transmission of pressure through sand and similar material, was given the services of two members of this party. These men acted as his assistants, relieving him of a great deal of routine work, yet not affecting his control of his own research problem.

An investigation of the web strength of girders has been carried on by the joint efforts of a member of the research staff of the materials testing laboratory and a member of the instructional staff in structural engineering. The research man was able to spend time rigging up special test apparatus, and to oversee the work of testing, the instructional staff man was able to keep the scope of the investigation properly correlated to current practice in design. The resulting piece of research was better than if either man had attempted it alone.

Dean C. L. Cory: I have known some teachers who were not good teachers primarily because they did not continue to be students in the real meaning of that word of the subject that they were teaching. In the earlier years of their academic career perhaps they were good teachers, but for some reason after considering themselves well established in their positions they failed to continue to be students or do any serious intellectual work outside of the class room.

I can think of nothing that will more surely tend to develop the highest intellectual activities of a teacher like research or original work. One difficulty is that original investigation or research in many institutions is received with about as much enthusiasm as one receives an invitation late in the afternoon to attend a dinner in the evening, the reason of the invitation being that, due to the failure of some one previously invited to accept, the host or hostess desires to obviate the embarrassing condition of having thirteen at the table.

I wish decidedly to emphasize the point Professor Jackson has so clearly developed. Research, to be of any worth, must be organized and carried on by the department rather than by one or two members thereof. The organization and proper supervision of research is of the greatest value in developing the highest qualities desirable in a teacher. At one time I had an idea that a man who is essentially interested in original investigation could not, at the same time, be a good teacher. In later years, however, it has become apparent to me that this is not the case. The benefit of research work to the graduate students as well as the undergraduate students is unquestioned; to the latter perhaps by example. Besides, there is great benefit to the teaching staff, inspiring every member of the department to endeavor that is really worth his while.

When in an electrical laboratory, for instance, you can have at hand the facsimile of a 600-mile, high tension transmission system containing resistance, capacity and induction in exactly the same relative proportions that these constants have in a regular transmission system in actual use; again, if there is available in such an electrical laboratory a specially designed oscillograph giving accurate electromotive force and current curves with frequencies up to 5,000 cycles per second, and the engineers of the large transmission companies as well as the United States government find it desirable to use such equipment in their investigation work, the inspiration to the students, graduate and undergraduate, must be of the greatest advantage in the routine instruction, which often is not necessarily interesting.

I am in accord with the fundamental principles set forth by Dean Walker, and it is always where we find new conditions and new problems that our scientific departments gain most.

Research work can only be effective if properly organized, and every member of the department should contribute something toward this most important feature of the work done by the department.

Professor Jackson: Dean Cory says there are unquestionable advantages to undergraduate students. If there is time I would like to have him explain the reasons for it. I agree with him, but I would like to have his reasons.

Dean Cory: The advantages are many. Those that come to my mind at this moment are that research adds zest and inspires enthusiasm not only to the undergraduates but to the staff of the department. Considering the undergraduates first, as a result of my observations it is decidedly worth while if a student, even as a junior, has an opportunity to see some experimental work begin. The result is that he not only takes a greater interest in that particular experiment, but it causes him to take a greater interest in all the work he does even as an undergraduate in that department. It may even mean that he may take a greater interest in all his university work and develop the proper attitude of mind toward his studies.

Seminars usually are conducted primarily for the benefit of graduate students, but if incidentally you can bring the undergraduates in contact with these new problems it is a tremendous advantage to them as well. If the research work of the department is properly organized there is a general uplifting of every member of the teaching staff, the graduate students and also the undergraduates.

Professor F. G. Higbee: There is one phase of this subject that I would like to bring to your attention, and that is the effect of research upon the departments teaching elementary subjects. I refer particularly to elementary subjects such as drawing and descriptive geometry. Perhaps I can focus your attention upon the point I have in mind by explaining to you that for ten years there has been a constant procession of instructors leaving my department to take up work in other departments or in other colleges. This has been the effect of research upon my department. Instructors are given time and are encouraged to take up research work but it generally works out to the disadvantage of the department in that the instructor often leaves as a result of this work. The direct effect of this upon the department is not good. It means that there has been a constant change of instructors, obliging us to fill the gaps with young men just out of college.

We have been hearing a great deal during this meeting about the "seventy-five per cent. requirement" of engineers. I believe, and there are others who share my belief, that drawing and descriptive geometry are subjects which offer wonderful possibilities in the development of those qualities which go to make up that requirement. Quite apart from the technical side of these subjects there is an educational side which rounds out a man's development in the direction of this seventy-five per cent. requirement. But in the hands of young instructors, men just out of college, this feature of these subjects is generally overlooked. It takes men with experience in life and in teaching to bring out the educational side of these subjects. And when, as a partial result of research work, I find it impossible to keep such men in my department you may understand why I make the claim that it is not an unmixed blessing.

There is just one other point I would like to make in this same connection. This is the danger of having an instructor lose the point of view he must keep if he would teach elementary students successfully. As a man progresses in his research work he is apt to lose this point of view, he is apt to advance beyond the point where he can successfully teach freshman students.

Dean A. A. Potter: The United States has the most inventive, the most resourceful and the most practical people on earth, but our success so far has depended to a considerable extent upon accidental conditions. Americans are responsible for 72 per cent. of the epoch-making inventions which have been discovered during the past fifty years, but we are dependent upon other countries for processes and machines required in our industries. We lead the world in large-scale production, but are unable without the aid of other nations to supply many of the things which we need in our industries and in our homes. The United States of America have great natural resources, but we must be satisfied to allow other nations with meager resources to gain and to hold the markets of the world.

The neglect of fundamental knowledge and its acquirement, our lack of patience to study, to reflect and to investigate, and our meager appreciation of the value of engineering research are among the main causes which are responsible for the inconveniences which the American people must suffer during the present European conflict.

Unless we recognize the value of engineering research, the United States will be dependent upon other nations. Without fundamental investigations it will be necessary for us to give up the control of foreign markets to such nations as recognize that expenditures for experiments are the best means of avoiding costly mistakes, and are the only methods for developing the resources and possibilities of a country and of a people.

Research in our engineering educational institutions will benefit not only the teacher and the student but also the industries and the people of this country. It is most gratifying that over fifteen engineering colleges are maintaining engineering experiment stations at the present time and it is hoped that every engineering teacher will soon appreciate the value of engineering research and that our colleges will take a leading part in developing the possibilities of our country and of our people.

Dean Walker: I cannot but feel that the most significant and impressive matter which has come before the organization this year—and last year, for that matter—is the report by Dr. Mann on the general situation existing in the schools of engineering in this country. We have all been impressed, I know, with that topic, and all have been wondering just what we might do with reference to setting in motion certain things, agencies which might have some influence in putting into effect some of the suggestions which have been made. Among all these, and in all of the work which we are doing and trying to do, we have to realize that if we are going to change our methods of teaching; if we are going to do anything which is more effective in the way of giving to our students the training we want them to have, develop character and all the various qualifications of which we have heard so much, we must realize that the first thing is the development of the teacher. It seems to me that it is the teacher primarily who must be considered, who is to be the chief actor in the program of improvement. It was with that thought in mind that I prepared the opening discussion on research as a factor in the school. My hope was that we might consider the whole proposition—primarily, at any rate—from the standpoint of the effect which research may have upon the men who are carrying the burden of teaching, and I have been glad to note the trend of the discussion.

To those who have read more in detail the paper which is printed in the June BULLETIN, it will be needless for me to add that I believe that our teaching men should be encouraged to do research work. In saying this I am not aiming to criticize at all the policy which has been adopted in various institutions, where many men have been engaged to give their major time to research. They are turning out a large amount of valuable work, which will mean much in the development of our industrial life.

It may be thought by some that I have chosen this subject with something in my mind relative to the proposition which is prominently before the country, to establish engineering experiment stations. I wish to say in that connection that I prepared my paper without that being in my mind at all. The value of the results which would come from such a measure would be very great; but again I say that my thought was that here we might profitably give a portion of the hour to the discussion of what we may do in the way of benefiting men who are engaged in teaching and are carrying the burden, in the way of providing for them this avenue for the exercise of their powers.

It is my policy in the institution with which I have to deal to encourage the men who are meeting students regularly to undertake various lines of outside work and I have gone to the extent of freeing them from a certain amount of teaching time so they may have the opportunity for it. I expect that during the coming year there will be a few men on our faculty whose salaries will be paid in part from the regular budget for carrying on teaching work, and in somewhat smaller part from the separate assignment for research; it being my belief that there will be not only some material results which will have intrinsic value but also that these men will themselves receive material benefit.

One word more: Yesterday, or the day before, when Professor Constant was giving the report of his Committee, which in the main had to do with the various activities of the teaching members of our faculties, I desired to speak of one particular phase of that question. I did not do it at the time, thinking the opportunity would come later. Under the general heading of research I have chosen to include various activities which might occupy the time of our men. One important point, and this is one which illustrates a condition which we have to work under in some of the western universities, which men of the eastern institutions may never have met, is that the administrator of a school must stand as a buffer between the members of his faculty and the state at large, especially the municipalities of the state. Demands come to us for work to be done, which work should properly be carried on by consulting engineers. Municipalities want the work done, but they do not want to pay for it. They have little idea of what it might involve. In our own case, I have to stand frequently as the buffer between these parties who are wishing to have work of this character done, and our men, who might be imposed and be required to perform the service for nothing. When we consider that which may be done profitably and wisely by the members of our faculties, it is necessary to look very carefully to the point that their time should not be overburdened, and that they should not be called upon unexpectedly to perform work which was not contemplated when their work was laid out for the year. I have indicated that in laying out the work for some men, we have planned that they shall give a certain time to research. We all see the injustice which would come if men for whom such provision had not been made were called upon to do the free work which the municipalities ask.

I am glad that Professor Jackson brought out the fact that the doing of research work prompts instructors in engineering to study more carefully their own teaching methods, doing so with reference to fundamental principles of education. It is the natural result which follows when men become accustomed to doing exact constructive work.

The circumstance mentioned by Professor Higbee illustrates the need of careful selection of both men for teaching and the subjects for research. If teachers are to be benefited by the outside work, that work must have some point of direct contact with the subjects taught. Freshman drawing and descriptive geometry are not subjects which lend themselves well to research as such, although some of the other activities which have been included in the discussion might apply. In passing it may be remarked the teachers in these topics are the only ones with engineering training, usually, who come in close contact with freshmen students. For this reason they have great responsibilities along with great opportunities. They should be studying men, engineers and their records, writing, perhaps, and bringing to their students the enthusiasm needed in special measure at that period.

There is one other thing which I want to bring before the meeting, because I think it is something in which we as educators should take a very live interest. There are several agencies in this country which are devoting their energies in considerable measure to the development of foreign trade and to foreign work in general. These activities are being directed largely toward South America and Russia. People who are doing that work most actively report that they are being continually balked by not being able to find men trained for the field. The Chamber of Commerce of the United States is entering this work in an active manner. I have here a letter just received this afternoon from the man who is directing their publicity campaign. He says that he is more thoroughly convinced than ever that a coöperative plan for the training of men is what will solve this difficulty.

What the Chamber wants is coöperation. I believe it is one of the legitimate activities, one of the legitimate ways in which schools may coöperate toward a desirable end. If we can say to our students or graduates, "Here is a definite proposition"; I believe we may do a real service to the country by bringing them back to the schools and giving them such additional training as we may profitably give. After that, of course, they would go to the particular concern which is interested in placing men, and complete their preparation for the work.

I speak of this, not so much that is concerned with the topic before us now, but with a view to stimulating coöperation with the Chamber of Commerce, and in the hope of interesting engineering institutions all over the country in this training of men for positions in these lines.

OCCUPATION AND DISTRIBUTION OF GRADUATES FROM ENGINEERING COLLEGES.

BY A. A. POTTER,
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AND
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Statements are often made that only a relatively small per cent. of graduates from engineering schools remain in engineering work. In order to verify this statement, a study was made of the occupations of alumni from over fifty representative engineering colleges in the United States. The results incorporated in this paper include graduates from classes 1901 to 1914 inclusive.

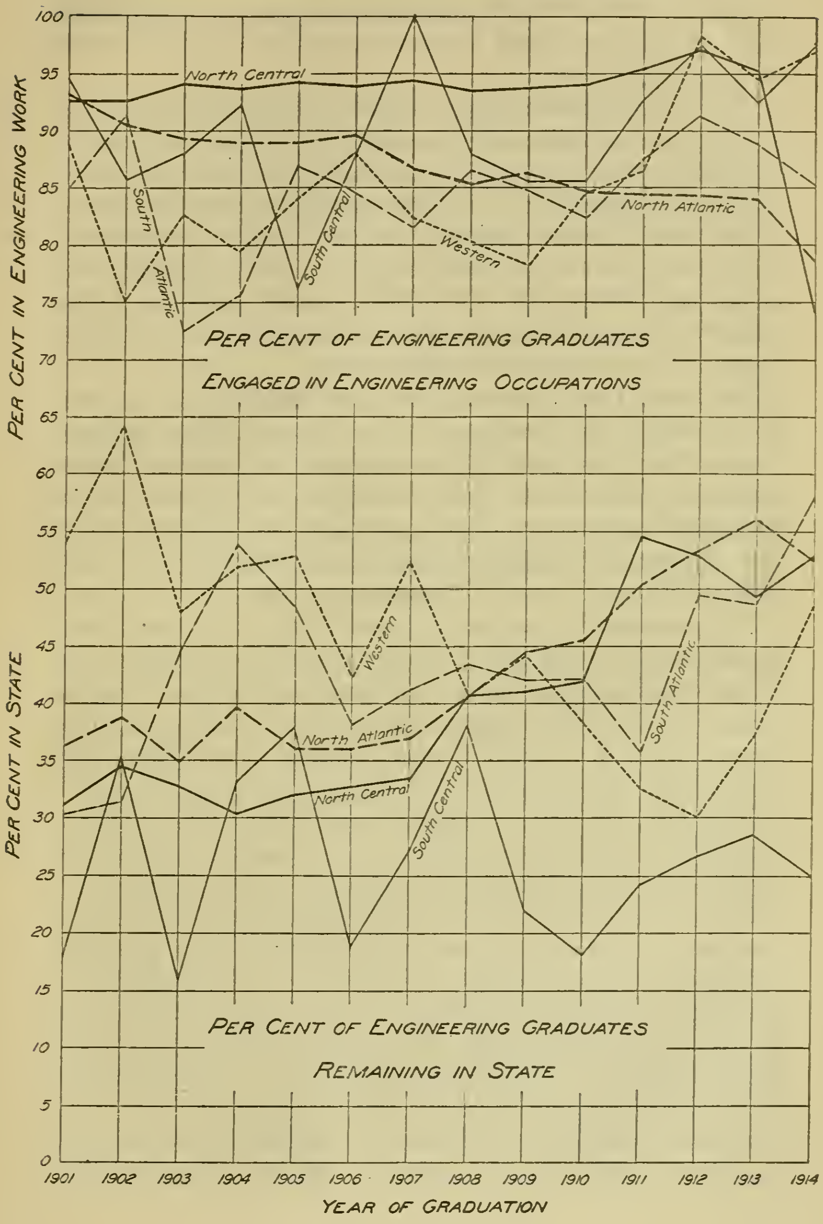
The records and percentages are compiled from 22,697 graduates whose occupation and residence was definitely known. Under engineering as occupation are included: practicing engineers, engineering draftsmen and designers, construction engineers, engineering salesman, teachers of engineering or of allied subjects, and engineering executives.

The institutions investigated and their locations are shown in the accompanying table.

In making this investigation, it was found that several of the leading engineering colleges kept no record of their alumni. Such records, if carefully kept up to date, should prove of great value to engineering education.

Percentages of Graduates Remaining in Engineering Occupations.

This investigation proves conclusively that 90.1 per cent. of graduates from the engineering schools of the United States remain in the occupations for which they were prepared.


Per Cent in Engineering Work
100
95
90
85
80
75
70
65
North Central
South Atlantic
South Central
Western
North Atlantic
Per Cent of Engineering Graduates Engaged in Engineering Occupations
Per Cent in State
60
55
50
45
40
35
30
25
20
15
10
5
0
Western
North Atlantic
North Central
South Central
South Atlantic
Per Cent of Engineering Graduates Remaining in State
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
Year of Graduation

The chart shows the percentages engaged in engineering work of graduates from engineering colleges in the various sections of this country.

The North Atlantic Group, which includes the institutions as given in the table, and represents 8,452 graduates, shows that the percentages remaining in engineering work vary from 79 per cent. to 93 per cent. The average percentage is 87.

The South Atlantic States (see table) show a greater variation, the limits varying from 72 per cent. to 92 per cent., with an average of 85 per cent. This greater variation is due mainly to the small number of graduates, which for this group is only 1,382 for the years 1901 to 1914.

The North Central Group (see table) shows the least variation. Taking the graduates in this group of the thirteen classes from 1901 to 1913, the variations are between 92 per cent. and 97 per cent. This group which is represented by 16 institutions and by 11,444 graduates, has 94 per cent. of the students who graduated during the thirteen years from 1901 to 1913 remaining in engineering work.

The variation in the South Central institutions (see table) is greater than in the North Central, the figures varying from 76 per cent. to 100 per cent. The general variation is similar to that in the South Atlantic institutions and for the same reason, which is a relatively small number of graduates, 725. The average for the South Central Group is 90 per cent.

Eighty-six per cent. of the graduates from western engineering schools (see table) remain in engineering occupations. In this group 694 alumni are included in the investigation.

There seems to be no definite relation between the occupation and the number of years after graduation from college, if the first two years are not considered. The occupations of graduates from any professional school during the first two or three years are of little importance, as the young college graduate must find himself by actual contact with the world. It is most gratifying to the engineering schools to know that over ninety per cent. of graduates in engineering are actually engaged in engineering occupations. Similar studies of graduates from law and from medical colleges should prove of much interest.

Distribution of Graduates in Engineering.

While making the investigation relative to the occupation of engineering graduates, a study was also made of the number of engineering graduates who remain in the state where the institution graduating them is located. This information is often asked for by legislators or executives at the head of state institutions. There is little argument against the fact that the main purpose of any state government is to aid in bettering the conditions of their citizens, irrespective of whether such citizens remain in the state or move to some other state. Many of our leading institutions of learning are devoting large sums of money to the education of people not only outside of the particular state where the institution is located, but also for the training of students from many foreign countries. Altruism must go hand in hand with education and it is only by such breadth of view that any college or university can best serve its purpose.

A study of the engineering graduates from the institutions as given in table (see chart) shows that 41.1 per cent. remain in the state in which they were educated for the engineering profession.

The northern and western groups of institutions retain a larger percentage of their graduates than do the southern states. This is to be expected on account of the development of the manufacturing and other engineering industries in the northern and western sections.

In the North Atlantic Section, 53 per cent. of the class of 1914 remained in the state, 46 per cent. of the class of 1910, 37 per cent. of the class of 1907, 35 per cent. of the class of 1903 and 36 per cent. of the class of 1901. An average of 42 per cent. of the graduates from institutions located in the North Central states remain in the state in which they were educated.

The South Atlantic Group shows 58 per cent. for the 1914 class, 42 per cent. for the 1910 class, 41 per cent. for the 1907 class, and 30 per cent. for the class of 1901. An average of 44 per cent. remain in the state where the institution from which they graduated is located.

The North Central Group shows 53 per cent. for graduates of 1914, 42 per cent. for 1910, 34 per cent. for 1907 and 31 per cent. for 1901. The average for this group, remaining in the state is 41 per cent.

The South Central institutions have 25 per cent. of the 1914 class, 18 per cent. of the 1910 class, 27 per cent. of the 1907 class, and 18 per cent. of the 1901 class, remaining in the state. In general the average is 27 per cent. with little indication as to the relation between the numbers remaining in the state and the years engaged in the profession.

The Western States show an average of 43 per cent. as remaining in the state.

In general, there is little difference in the percentages of graduates remaining in the state after graduation from engineering colleges in the various sections of the country. The nature of the engineering profession often requires frequent change of position. This is particularly true in the case of civil engineering graduates.

In addition to these figures by classes, corresponding data for the total graduates of several years were obtained from several engineering colleges:

Of the graduates from the University of Missouri, classes of 1908–1913 inclusive, about 90 per cent. are engaged in engineering and 60 per cent. are now in the state of Missouri.

The Agricultural and Mechanical College of Texas gives for the classes of 1900–1915 inclusive, as 82 per cent. now engaged in engineering and 67 per cent. in the state of Texas.

University of Washington (Seattle), for graduates during the period 1901–1915 inclusive, 85 per cent. as now engaged in engineering and 66 per cent. in the state of Washington.

University of Vermont, classes 1901–1915 inclusive, 90.4 per cent. engaged in engineering and 20.2 per cent. in the state of Vermont. Of the graduates during the past five years, 33 per cent. are still in Vermont.

University of Maine, of the graduates during the past ten or fifteen years, at least 95 per cent. are engaged in engineering. Of classes previous to 1910, 26 per cent. are in the state of Maine; and since 1910, 29 per cent. are in the state.

North Dakota Agricultural College, gives 85 per cent. engaged in engineering and 41 per cent. in the state of North Dakota.

Vanderbilt University has about 87 per cent. of its alumni in engineering work.

In this miscellaneous group, some of the advantages in engineering work were given directly by the institution. Hence, they were probably not all computed on the same basis. In general, the averages compare favorably with the averages of the other institutions investigated, and aid in showing that the engineering colleges of the United States prepare their graduates for active work in the industries.

LOCATION OF INSTITUTIONS INVESTIGATED.

Group I—North Atlantic.

Carnegie Institute of Technology,
Clarkson College of Technology,
Columbia University,
Lehigh University,
Massachusetts Institute of Technology,
New Hampshire State College,
Pennsylvania State College,
Pennsylvania University,
Rhode Island State College,
Rutgers College,
Stevens Institute of Technology,
Tufts College,
University of Pittsburgh,
Vermont University,
Worcester Polytechnic Institute.

Group II—South Atlantic.

Clemson Agricultural College,
Delaware College,
Georgia School of Technology,
North Carolina A. & M. College,
University of Florida,
Virginia Polytechnic Institute,
West Virginia University.

Group III—North Central.

Armour Institute of Technology,
Case School of Applied Science,
Iowa State College,
Iowa State University,
Kansas State Agricultural College,
Kansas University,

Michigan Agricultural College,
Michigan University,
Minnesota University,
Ohio State University,
Purdue University,
Rose Polytechnic Institute,
South Dakota State College,
University of Illinois,
University of Wisconsin,
Washington University (St. Louis).

Group IV—South Central.

Oklahoma A. & M. College,
University of Arkansas,
University of Kentucky,
University of Tennessee.

Group V—Western.

Colorado University,
Idaho University,
Nevada University.

A PLEA FOR THE FURTHER STUDY OF EFFICIENT METHODS IN THE ADMINISTRATION OF AN ENGINEERING COLLEGE.

BY C. C. MORRIS,

Assistant to the Dean, The Ohio State University.

The purpose of this paper is to call attention to the need of further systematic study of efficient methods of administration in engineering colleges. Reference is not made to the larger problems of policy and control which must be met and solved by the dean. Those problems are in mind which must be met by the one in charge of the details of the office work. Problems involving the preparation of teachers of engineering, their summer employment, the time to be spent by them in work outside of their regular class work, the relation of the engineering college to the university of which it is an integral part, are all problems for the dean. But how best to prepare for the student a suitable schedule, how to keep in constant touch with him, how to help him when he needs help, to lighten his load if it is too heavy, how best to keep him in line when he begins to waver, how best to find out if he is, or if he is not, fitted for the work of an engineer, these are the tasks of the one who is assisting the dean. All this work requires machinery, and this machinery may be efficient or it may be inefficient. So far as the writer knows, there is no place where an inexperienced assistant may go to find out what methods have been successful. When the writer was appointed to his present position, he very naturally was anxious to find out all he could about the duties of his office. He was surprised to find that literature upon the subject was practically nonexistent. This paper is the result of his efforts to work out his own salvation. As progress has been made, the thought suggested itself that it would be a good plan to gather together in one pamphlet all the best methods of procedure of the various colleges.

In an effort to find out how other institutions were carrying on their office work, a trip to several of the larger institutions was made. In each, one or more methods were found which had been tried out and found particularly efficient. In one institution, that particular phase of the work to which special attention had been given, showed marked development. In another institution, an entirely different phase had been worked out and developed. There is no doubt but that every institution has something, either a detail of organization or some efficient plan of dealing with students that every other institution would profit by knowing. That there is a great variety of methods of various degrees of efficiency and inefficiency is apparent even to the casual observer, and that there is a large field here which should be carefully worked over is evident.

This is suggested, not with the thought that any institution might want to adopt in toto any method or device used by another institution, but with the hope that each would be able to find something worth working over and adapting to its own local needs.

The writer is fully aware of the fact that there are many details of office work in which a large majority of the members of this Society are not in the least interested, yet in every engineering college there are two or three that are vitally interested in everything that tends to facilitate the task of dealing with students, and to lighten the load of the administrative officers.

The methods of administration of each college are more or less the result of local conditions and are directly affected by those of the university of which it is a part. Their growth has taken place in a haphazard sort of way and has been largely due to chance. This may be explained by the fact that not until recently has the dignity and importance of the work been realized. In the past there has been a secretary of the college who regarded his office duties as secondary to his teaching duties. As soon as his conscience allowed him to do so, he passed on his secretarial work to someone else and returned to his teaching. The office was thought of only as a temporary abiding place and not worth his best efforts. It is evident, however, that the work is now coming into its own, and it is demanding the best efforts of able men. The assistant to the dean is in the majority of cases a man of full professorial rank, and often the head of a non-technical department.

One of the most troublesome questions that occupies the attention of the administrative officers is that of schedule making. At The Ohio State University there is a system of preregistration. During the summer vacation, there is prepared by the assistant to the dean a schedule for each student. These cards are made out in triplicate, one for the student, one for the registrar, and one for the dean. Then, after they have been sent to the registrar's office and scored, the student's card together with his fee card is sent to him by mail. The fees are paid by mail and the student is ready for class work before the opening of the semester. There are some very serious objections to this plan. The schedules are made without a conference with the student. He may have plans unknown to the schedule-maker, for making up back work, or, if the student is dependent upon his own resources, it may be absolutely necessary to take into account the time which must be spent in outside work. This makes necessary a considerable number of changes and a large number of enrollment cards, prepared in the registrar's office when the original schedule was scored, are of no value. A great deal of this confusion could be avoided if it were possible to have the schedule bulletin completed by the first of March preceding the school year. Opportunity would then be given for interviews and the student's wishes could be taken into account. As a conservative estimate, I would say that thirty per cent. of the students of our college of engineering are to a greater or less extent dependent upon their own resources. How to plan the schedule-making so that these deserving men will get adequate attention, yet at the same time to save the whole scheme of registration from utterly breaking down is indeed a difficult problem. The plan outlined above has many advantages. The responsibility is centralized. The one in charge of the work is supposed to be an expert in making combination of hours. He is conversant with the prerequisites of all the courses and he must see that these are met. If the student becomes irregular on account of ''conditions'' or ''failures,'' he must see to it that those subjects around which his whole course has been built go on his class card. Otherwise, as has often been the case, the student will find himself in the position of being ineligible to a full schedule. He must see that the cards are cleared as the student goes forward and that no subject is left behind. He must see that all requirements for graduation are being met. As he works, he must keep in close touch with the score sheet in order that the balance of the sections may be maintained. All these duties may be done best by one central authority. This plan, so far as I know, is not followed by any other engineering college. Usually there is a committee on schedules made up of the heads of departments which meets with the students on registration day. The students are grouped according to their classification and the committee aided by members of their respective departments spend a day or two making schedules. Often as high as fifty or sixty are working at the same time. The offices are crowded to the limit and long lines of men spend hours awaiting their turn. Confusion is everywhere. Some men take their task conscientiously, others hurry them through. Since the art of schedule-making is one that can only be learned by experience, a great many unbalanced schedules must result. Again, it is difficult to get men who are heads of departments and who are busy with outside activities to take proper interest in a work which they regard as more or less routine in character. The advantages of a schedule committee are, however, self-evident. Each student has the opportunity to talk over his plans and purposes. He comes in rather close contact with men of his own department, and often acquaintanceships formed under such circumstances are of great value to him.

Another question to which the writer has given much thought is this: how far can one go in putting the student upon his own resources. Some colleges make for him in an arbitrary way his schedule, keep track of every absence, solicit from his instructors reports as to his scholarship at frequent intervals, and in every way treat him as one devoid of initiative of every kind, and unable to attend to his own affairs. The college is indeed both father and mother to him. The student is deprived of the responsibility of making his own choices, of planning his own work and developing himself along the line of self-reliance. It is the opinion of the writer that administrative officers must after all remember that the boy, not the machinery of the administration, is the important factor. Where to draw the line between that for which the student may be held responsible and that for which the office may be held responsible, so that the student may have the greatest possible freedom, and so that the dignity and effectiveness of the administration may be preserved is a problem of great importance.

I have mentioned two subjects which should be carefully considered. There are many others that are worthy of study by a committee made up of those who are engaged in administration of what might be called the student side of the college and it is the suggestion of this paper that either one of the committees now in existence be asked to do this or that a new committee be created for the purpose.

ENGINEERING EDUCATION AND COÖPERATION AMONG ENGINEERS.*

BY JOHN F. HAYFORD,

Director, College of Engineering, Northwestern University.

The Society for the Promotion of Engineering Education is vitally interested in the improvement in the profession of engineering which would be produced by closer coöperation among the very numerous engineering societies.

There are strong interests which the many engineering societies have in common. They should coöperate for those interests. The activities of the various engineering societies are largely confined to technical engineering matters. In placing strong emphasis on these, many less technical matters which are important to engineers have been largely overlooked, and these are largely matters of common interest to the whole profession.

In these matters the teachers of engineering are as much concerned as those who are in engineering practise. There is no clear line of distinction between the two groups. The teachers of engineering are in many engineering societies. Their problems overlap and agree in many particulars with those of the practising engineers, especially in all problems of the relations between men, the training of men, and the selection of men for particular projects. The teacher of engineering takes certain men from the high schools and selects, trains, and develops them to the best of his ability for four or five years. The graduates then go out into the engineering work of the world. Those in executive control of engineering work then find that one of their most difficult and important tasks is to continue for thirty or forty years the training and development which was carried forward a few steps in college.

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* Read before the Conference on Engineering Coöperation, in Chicago, April 13th, 1916.

Coöperation among engineers would bring broader views and greater opportunity. These in turn would bring corresponding improvements in the methods of teaching in engineering and in the opportunities of colleges of engineering.

Engineers are too prone to become so interested in, and busy with, the details of their daily regular work that it is difficult to get them to look at the broader, higher things which concern them. Similarly the student is so busy with particular problems, with certain pages of certain text books, and so interested, that it is difficult to get him to look up. The problem of bringing about broader views, producing a vision of the greater opportunities, is very similar in the two cases.

With more coöperation and broader outlook among engineers there would be sure to come more emphasis on character and judgment, and ability to deal with men, as essential to engineering success. The corresponding improvement in education would follow promptly.

I am confirmed in my belief that a broader outlook on the part of engineers would lead to improvement in what they would demand from the teachers of engineering, when I picture in retrospect such demands as have been made in the past. It is my experience that when recent graduates are asked for suggestions for improvement in a college of engineering they usually suggest more narrow technical training, more information. It is equally true that when engineers of long experience, especially in positions where they have dealt with many engineers, are asked for suggestions, they advocate more general training, more emphasis on the quality of teaching, and more development of right habits of thought and action.

I feel confident that you may depend upon the Society for the Promotion of Engineering Education to be cordial toward coöperation. That is the habit of the society and of its members. Teachers of engineering are in the habit of keeping closely in touch with engineers and with engineering work. The Society for the Promotion of Engineering Education, organized for the purpose indicated by its name, has always welcomed practising engineers in its membership and on its program. More than one tenth of its present membership are men engaged actively in the practise of engineering.

THE MEANING OF INTEGRATION IN CALCULUS.

BY JAMES E. BOYD,

Professor of Mechanics, The Ohio State University.

The Society for the Promotion of Engineering Education has recently given considerable attention to the fundamental notions of calculus. At the Princeton meeting several papers were presented and the lively discussion which followed showed the interest in the subject.

Some writers insist that dy and dx never represent quantities and that dy/dx is not a fraction but merely a single expression for the limit of a ratio. This point of view is convenient in differential calculus but is sometimes so applied as to introduce needless confusion into the integral. In the applications of integral calculus it is necessary to form expressions for the increments of the physical or geometrical quantities involved. These expressions must represent something which may be visualized, and require the use of differentials. In making the connection between these expressions and the definite integrals some writers are not consistent; they define dy and dx as not representing quantity and then proceed to use them as differentials. Some are more careful, employing Δy and Δx for finite differentials and defining the integral sign and the final dx in $\int f'(x)dx$ as together constituting a single symbol for the operation of finding the function of x whose first derivative is $f'(x)$. No objection can be made to the logic of this method. It is not easy for the beginner to grasp or to connect with the idea of integration as a summation. Some writers of applied mathematics use it consistently, always expressing the increment by means of the finite differential and discussing the conditions as this differential approaches zero as a limit. Considered as an exercise in integration, a little of this process of practically deriving the principles of calculus each time a problem is solved may be helpful to the beginner, but as a method of working out applied mathematics it puts too much emphasis on the machinery of the solution, distracts the attention from the physical problem, and is wearisome to the reader.

A second group of writers define dy and dx as representing very small quantities. This form of definition makes it easy to understand integration as a summation, giving a result which is approximately correct. To account for the fact that the results of integration are not approximate but are absolutely correct it is supposed to be necessary to define these differentials as infinitesimally small. The nature of some of these definitions is well illustrated by the examples given by Professor Huntington in his paper before the Princeton meeting.

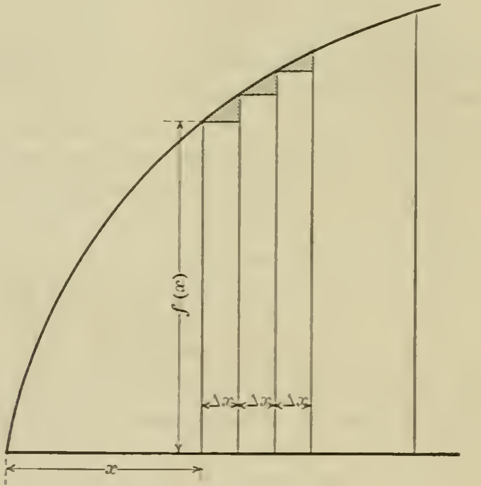

Fig. 1.

In taking up the definite integral it is customary to begin from the standpoint of the determination of an area. This area (Fig. 1) is divided into rectangles of height $f(x)$ and width Δx and the total area is said to be approximately equal to the sum of these rectangles. This total area is represented algebraically by $\Sigma f(x)\Delta x$. The small shaded spaces of Fig. 1 show the difference between this approximate total area and the true area below the curve. As Δx is made smaller the number of these residue spaces is increased but their total area is diminished; and at the limit, when Δx becomes dx, the residue is said to vanish and the exact area is represented by $\int f(x)dx$. Various devices are used to show that the residue actually does vanish and that integration regarded as a summation is equivalent to the inverse of differentiation.

It is not at all necessary that the differential should be infinitesimal in order to make the results of integration correct. The differential (Δx) may be relatively large without any residue whatever. This is because the terms containing Δx^2 and the higher powers of Δx (frequently called differentials of the second and higher *orders*) have been discarded in deriving the rules for differentiation, and these terms represent exactly the residue which is not accounted for in forming the expression for integration. In Fig. 1, $f(x)\Delta x$ is the term which contains Δx in the first degree, while terms which contain Δx in the second and higher degrees represent precisely the shaded residue. The greater part of this residue is a triangle the base of which is Δx and the altitude the second term of the expansion of $f(x+\Delta x)$. The third term is equivalent to the area enclosed by the X axis, the parabola $y=kx^2$ and the ordinate $x=\Delta x$, where k is the coefficient of the second power of Δx in the expansion of $f(x \times \Delta x)$. The fourth term is equivalent to the area bounded by the X axis, the cubical parabola $y=k'x^3$, and the ordinate $x=\Delta x$ where k' is the coefficient of the third power of Δx in the above expansion. The area of the third term is $(k\Delta x^3)/3$, that of the fourth one is $(k'\Delta x^4)/4$ and so on.

When we consider $\int xdx=x^2/2$ we are accustomed to think that $x^2/2$ is the sum of a great number of terms of the form of xdx; it may as well be regarded as the sum of one or more terms of the form $x\Delta x+(\Delta x^2/2)$.

To justify these statements and illustrate their meaning we will now consider a few simple examples, but before doing this it is advisable to *define* one term which we will use and to state the meaning which we propose to give to two common expressions of calculus.

The complete differential of a function is the entire increment of the function. The complete differential of x^3 is $3x^2\Delta x + 3x\Delta x^2 + \Delta x^3$.

The differential coefficient is the coefficient of the first power of Δx in the complete differential.

The integral of $f'(x)\Delta x$ is that function of x for which $f'(x)$ is the coefficient of the first power of Δx in the complete differential.

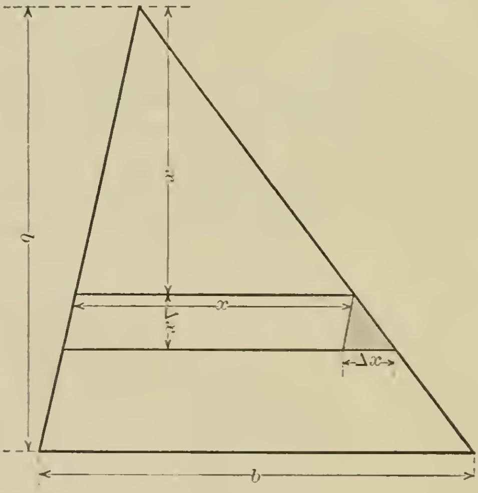

FIG. 2.

These definitions require no change in the methods of integration but merely give a different interpretation to the operation. In many cases integration is a mere algebraic process. Important applications can be made which involve in no way the ideas of limits or infinitesimals, and many more can be made which require the use of the limit of an infinite series but do not require that the differentials be regarded as infinitesimal.

Fig. 2 is a triangle of which the base is equal to the altitude. We will find the area, taking the vertex as the origin and the X axis perpendicular to the base. An element is made up of the parallelogram of area $x\Delta x$ and the shaded triangle of base and altitude Δx which is similar to the entire triangle and to the triangle of base and altitude x. If A represents area

$$A = \int x\Delta x.$$

We recognize $x\Delta x$ as a quantity of the second degree and as the first term of the complete differential of $x^2/2$. Expanding $(x + \Delta x)^2/2$ we find the complete differential to be $x\Delta x + (\Delta x^2/2)$. If the area of the triangle of base and altitude x is $x^2/2$, the area of the similar triangle of base and altitude Δx must be $\Delta x^2/2$ so that there is exact correspondence between the element of area and the complete differential.

To find the area between two lines $x = a$ and $x = b$ we may substitute these values as limits in the integral $x^2/2$ and get $(b^2 - a^2)/2$. Instead of using limits in the integral we may substitute $x = a$ and $\Delta x = b - a$ in the complete differential.

$$x\Delta x + \frac{\Delta x^2}{2} = a(b - a) = \frac{(b - a)^2}{2} = \frac{b^2 - a^2}{2}.$$

If we let $x = 0$ and $x = b$ we get the area of the entire triangle from the last term of the complete differential.

Having determined the first term of the complete differential from the geometry of the problem the last term may be obtained without getting the integral and the area calculated without any use of integration.

Another example is that of finding the moment of the triangle of Fig. 2 with respect to an axis through the vertex parallel to the base. The moment of the parallelogram is its area $x\Delta x$ multiplied by distance $x + (\Delta x/2)$ and that of the shaded triangle is the product of $\Delta x^2/2$ multiplied by $x + c\Delta x$, where c is the ratio of the distance of the center of gravity from the vertex to the length of the median. The term which contains Δx in the first degree is the one obtained by multiply-ing the area of the parallelogram by x. This is $x^2\Delta x$ and is recognized as the first term of the complete differential of $x^3/3$. The complete differential is $x^2\Delta x + x\Delta x^2 + (\Delta x^3/3)$. The entire moment is $x^2\Delta x + x\Delta x^2 + (c\Delta x^3/2)$ which corresponds exactly with the complete differential provided $c = \frac{2}{3}$. If the moment of the triangle of height x is $x^3/3$ its center of gravity is at the distance $\frac{2}{3}x$ from the vertex making $c = \frac{2}{3}$ for this triangle; it must have the same value in the similar small triangle, and the correspondence is exact throughout.

Instead of the first term of the complete differential we might get the second term and deduce the integral or the complete differential from it.

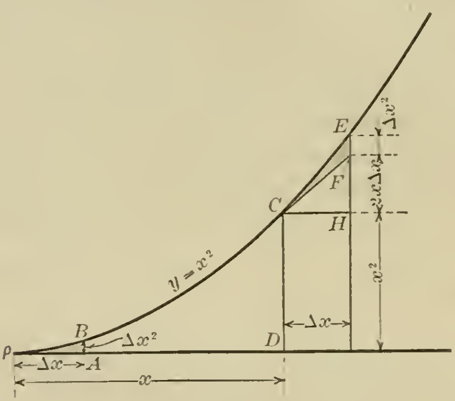

FIG. 3.

Fig. 3 represents the integral of $x^2\Delta x$ in another form—this time as an area. The ordinate at the left of an element of area is x^2 and that at the right is $(x + \Delta x)^2 = x^2 + 2x\Delta x + \Delta x^2$. The first term of the complete differential is the rectangle of area $x^2\Delta x$ from which the integral is seen to be $x^3/3$ and the complete differential is $x^2\Delta x + x\Delta x^2 + (\Delta x^3/3)$. The second term of the complete differential represents the triangle of base Δx and altitude $2x\Delta x$, this altitude being the first term of the complete differential of x^2. The third term must represent the shaded space CEF if we are to have exact correspondence between the complete differential and the entire element of area. The shaded space *CEF* is equal to *PBA*, since the horizontal distance *CH* is equal to *PA* (both being equal to Δx), and the length of the vertical elements at any given horizontal distance from the vertex is the same for both (being Δx^2). If, then, the area of *PCD* is $x^3/3$ the area of *PBA* and of the equal *CEF* must be $\Delta x^3/3$ and the correspondence is exact.

This method may be continued for all functions of the form of x^n where n is a positive integer, and the integration of these functions shown to be merely an algebraic process. The differential may be of any size. Instead of integrating between limits, the complete differential may be written from the form of the first term and the result calculated by substituting the values of x and Δx.

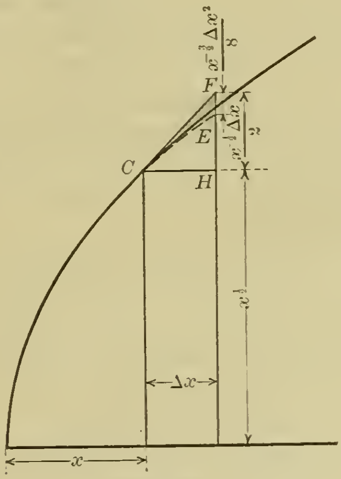

FIG. 4.

Fig. 4 represents the integral of $x^1 x$. The second term of the element of area is the triangle of base Δx, altitude $x^{-\frac{1}{2}}\Delta x/2$, and area $x^{-\frac{1}{2}}\Delta x^2/4$. The altitude of this triangle is the first term of the complete differential of $x^{\frac{1}{2}}$. The third term of the element of area is the shaded figure *CFE*, the vertical height of which, measured from the line *CF*, is $-x^{-\frac{3}{2}}\Delta x^2/8$, the second term of the complete differential of $x^{\frac{1}{2}}$. The area of *CFE* is the product of $-x^{-\frac{1}{2}}/8$ multiplied by the area enclosed by the curve $y=x^2$, the X axis, and the ordinate $x=\Delta x$. This area is equivalent to that of *PBA* (Fig. 3), and is $\Delta x^3/3$, so that the area of *CFE* is $-x^{-\frac{3}{2}}\Delta x^3/24$. In a similar way the next term of the element of area is found to be $+x^{-5}\Delta x^4/64$. From the first term the integral is recognized to be $\frac{2}{3}x^{\frac{3}{2}}$, the complete differential of which corresponds exactly with the element of area.

When the complete differential is an infinite series, as in this case, the area between any two ordinates may still be computed to any desired accuracy provided the ratio of Δx to x be such that the series is convergent. It is not necessary that the differential of x shall be infinitesimal unless x is infinitely small. (In the problem above, the entire area, from $x=0$ to any ordinate, may be calculated from the complete differential using $\Delta x=-x$. The series converges, but very slowly.)

As a check on the integral the element of area may be taken parallel to the X axis, giving the integral of $y^2\Delta y$, so that the student may see that even when the complete differential is an infinite series, exact results may be obtained by the use of finite elements.

Any problem involving integration between limits may be solved in the usual way, or the value may be calculated with finite increments. When the complete differential has a limited number of terms the results of the two methods agree exactly. When it is an infinite series they may be shown to agree to any desired degree of accuracy.

The complete differential may be determined by the methods used in the preceding problems or by Taylor's theorem. It may be employed, instead of the ordinary integration, in the solution of many important applications of mathematics, such, for instance, as the derivation of the equation of the elastic line of a beam or column. The results of the use of the complete differential are frequently easier to interpret than those secured by integration.

A few simple examples like these should be sufficient to show to the student that differentials need not be infinitesimal in order that the results of integration may be correct, but that the troublesome residues are fully accounted for by the terms of the complete differential which are usually discarded. They are not presented as substitutes for the ordinary methods of integration, but merely as side lights which may help to clear up some of the confusion which seems to exist in regard to this subject, and show that differentials are finite realities, and not mere "ghosts of departed quantities."

SOME THOUGHTS ON ENGINEERING EDUCATION.

BY A. B. McDANIEL,

Assistant Professor of Civil Engineering, University of Illinois.

These remarks are not intended to be a comprehensive discussion of the subject of engineering education, but simply to touch upon a few of the noteworthy features.

Dr. C. R. Mann's interesting and timely report has brought to our attention many of the faults of present day technical instruction. A proper consideration of this report should at least arouse us from our unfortunate state of apathetic indifference and self-satisfied contentment, and lead to a well-defined movement for constructive reform.

The full import of Dr. Mann's criticism and that of other educators and engineers is that there is startling inefficiency in our engineering schools. Presumably these criticisms are based on a study of the output; the average engineering graduate. Is the graduate engineer as he enters his professional career from college absolutely useless as some claim, or has he potential power for future usefulness? Doubtless the judgment of the critic will depend upon the point of view. Does the average employer expect the young graduate to be a full fledged engineer, or simply an inexperienced man with a thorough knowledge of the fundamental principles of pure and applied science? Certainly it would be reasonable to expect the latter, and yet few of our average engineering graduates fulfill the requirements of the latter condition. Apparently not if we are to believe the current criticism of a large number of employers of young men. The claim is often made that the average technical graduate lacks initiative, self-reliance, mental power and force; is possessed of a vast stock of unassimilated knowledge and an overweaning conceit, has a passion for novelty and a disregard for age and experience. Ferrero said of the young men of Rome in the time of Cæsar, ''The passion to read deep and widely, to fill the mind with great generalizations and all-embracing theories; to fathom the very depths of Being was becoming an enthusiasm, common among the younger generations; but they combined with it an impatient delight in novelty for its own sake and an insistent craving for fineness of execution and perfection of detail which had been entirely foreign to their elders.'' The speaker believes that this statement is largely true of the younger generation of today. The characteristic of the present age—great development, constant change and luxurious standards of living—are doubtless largely responsible for this condition of affairs. But are our schools not encouraging this unfortunate attitude toward life in their students? Is not the over-emphasis of the elective system, the introduction of a large number of subjects of a purely descriptive character and the high degree of specialization in every branch of applied science a tendency to cater to the wishes of students who desire to attain a vast mass of ill-assorted, restricted facts at the least expenditure of mental effort and in the shortest time? The average student is immature, short-sighted and mercenary. He views a college course largely upon the basis of its ready and immediate capitalization value. A Chinese student of high standing said to me upon securing his master's degree two years ago, ''Professor, it is a Chinese puzzle to me to understand how I am to do practical work with so little knowledge of the details of engineering construction.'' After a year's experience on railroad construction in the southwest he wrote me, ''I am learning the details by the thousands and with such ease. Now I know why you drilled in the fundamentals of our courses.''

Thus the young Oriental engineer worked out for himself the apparently inexplicable Chinese puzzle and discovered that the value of technical training lies not in the accumulation of a great store of detailed information but in the acquisition of the power to observe accurately, to reason correctly, and to act quickly and truly. The speaker believes it is largely immaterial what course a student takes in an engineering school if he receives the training which develops in him intellectual power, initiative, self-reliance and resourcefulness. Of four of the teachers of professorial rank in the department of civil engineering in one of the largest state universities of the Middle West, one graduated as a mining engineer, another as a mechanical engineer, a third as an architectural engineer, and the fourth with only an academic training from a small eastern college.

The speaker has noted with great concern the tendency in many of our larger institutions to encourage research and literary work among their faculties on the plea of the desirability of contributing to the sum total of human knowledge and of keeping abreast of the times. No one will refute the argument that engineering or any other professional field can not be successfully taught solely out of books and that the real virile teacher must keep up with the progress of his profession both by practical experience and research. But it is only the very exceptional performer at the circus who can ride three horses around the ring without falling between them. So in the educational arena, the average teacher should devote the major part of his time and energy to either teaching, practical work or research, if he wishes to make a success of any one.

However, *the teacher should primarily teach.* Of what value is his instructional ability to the students if a large share of his time is spent in the research laboratory or in a distant commercial field? An assistant dean of one of our large engineering schools recently told me that students often came to him and stated that they could rarely find certain professors in their offices outside of classroom hours.

The speaker believes that the problem of engineering education is not one of *technology* but one of *education.* The typical curricula of our present-day engineering schools may be likened unto a tree which has attained marvellous growth in a short time and has run to "top" foliage. The present course of study should be pruned down so as to eliminate a great deal of the highly specialized work and to produce a general course in applied science which would give a thorough training in the fundamental principles which the broadly trained engineer should know.

A professor in a large middle-western university was recently asked as to the ethical and moral standards of his students. He replied: "I don't know anything about the character of my students. I am teaching them history." And yet that same man would be grievously insulted if any one told him he was not doing his full duty as a teacher. The following quotation is taken from a letter published in a recent number of an engineering journal. "Character and integrity should be taken as a matter of course, but character is not formed without experience. Efficiency, judgment. perspective, understanding of men and executive ability can only come from experience, and can not be taught in any engineering school."

It is true that experience and those qualities which largely make for success in a material sense can only be acquired in the great University of the World's Work, but is material success the chief aim of man and is imparting knowledge the sole function of the teacher? The speaker has often been impressed with this opinion when he has heard eminent teachers eloquently urge their students to go out into the world and lose no time in acquiring fame, reputation and great incomes. that these things may serve to reflect glory on themselves and on their alma mater. God forbid that our younger generation is striving solely for these transitory baubles of the material world!

Truly successful is the teacher who arouses his students to a thirst for learning and a passion for labor, who instills into his young companions the high ideals of faith in God, love of man and public service. Every young engineer in entering upon his professional career if he wishes to attain the success that endures and to reap the harvest of "work well done" must be imbued with the spirit of the humble Oriental which is so beautifully expressed in the following lines:

Abou Ben Adhem (may his tribe increase!)
Awoke one night from a deep dream of peace,
And saw within the moonlight in his room,
Making it rich and like a lily in bloom,
An angel, writing in a book of gold:
Exceeding peace had made Ben Adhem bold,
And to the presence in the room he said.
"What writest thou?"—The vision raised its head,
And with a look made of all sweet accord,
Answered, "The names of those who love the Lord."
"And is mine one?" said Abou. "Nay, not so,"
Replied the angel—Abou spoke more low,
But cheerily still and said, "I pray thee, then,
Write me as one that loves his fellow-men."
The angel wrote, and vanished. The next night
It came again, with a great awakening light,
And showed the names whom love of God had blessed,
And, lo! Ben Adhem's name lead all the rest!

THE HUMAN SIDE OF ENGINEERING.

BY F. H. NEWELL,

Professor of Civil Engineering, University of Illinois.

The attitude of the ordinary young engineer seems to be that of studying the economics of materials rather than of men, of considering very carefully all the minor points of this side; but of having a profound contempt for anything that has to do with the economics of mankind as a factor of construction. We are coming gradually to the point of considering that the persons we employ are *men,* and that their reactions are governed by laws which are as interesting as those which govern material. The most interesting study is man; as we get older, we appreciate the practical importance of studying men; and we also appreciate what the young engineer seldom does—that these laborers, often apparently the outcasts of society, are men. It is a shock to some of these youngsters to really understand that fact, and to get it into their consciousness. When they do their whole attitude toward their work is different.

The successful engineer is beginning to appreciate the economics which apply to men, as he gets deeper into the work of keeping them on the job, of enthusing them to that point where they will stay with him, not merely on the day's routine, but in case of emergency for a twenty-four-hour day when necessary to save the great work which he may have under construction.

In our educational system we should try to get into the mind of the embryo engineer a few things beyond those relations to the mere material substances he is to handle and yet do this without adding more courses to an already overloaded system. The problem before us is to get into the head of the youngster the fact that a large part of his success depends on his handling men; and that he must begin to learn men as early as possible in his college course, in spite of the handicap which surrounds him in college with its peculiar surroundings which differ so widely from anything he will experience afterwards. It is our problem to teach about men when the student is not in contact with the type he will work with when he leaves college, especially if he goes out on large public works, and is immediately brought into contact with the great body of individuals whom we classify as day laborers. The solution of this question has been brought about in part through coöperation with such organizations as the Young Men's Christian Association and others, who are trying to bring college men into contact with the great mass of humanity that make up the laborers and the ordinary citizens of the commonwealth. It is proper to urge and even insist that the Y. M. C. A. or some such institution shall be recognized in planning large engineering work and that our young men shall take part in all the social work which brings the engineer in contact with his laborers, such contact that he may know them without involving any of the familiarity which may breed contempt. For example, in more modern works when starting a construction camp to be occupied for six months or six years, it is now considered wise to put up fairly decent quarters with rough, but clean bath-houses, and an amusement hall where the men can be entertained properly during the eight hours of recreation. On governmental work there are supposed to be eight hours of sleep, eight hours of work, and eight hours of idleness. It is just as much the duty of the engineer in charge to provide suitable diversion in that eight hours of idleness and thus keep his men fit for work, as it is to economize in the use of his materials of construction. Unless he is keeping his organization in good, effective trim, he is losing money.

The paper on this subject prepared by Mr. Rindge and printed in the Bulletin of the S. P. E. E. is worthy of careful study. It represents a recent development. The point to be brought out is, to what extent can our young men in college rub elbows before graduation with the type of men they will have to work with in their later life? The answer suggested by the Y. M. C. A. work is, through doing a little teaching, perhaps going into settlement work nearby—because every college is within close reach of the abodes of foreigners and laborers who can be helped, and who can in turn help the young engineer. This is what the industrial service movement has been doing throughout the entire country. Started at Yale, it has spread through two hundred and fifty colleges and universities. The paper so recently revised goes on to give a list of proposed courses that might be given, with lectures and outside reading. Mr. Rindge closes by asking the question, "Have the experiments been justified by the results?" His answer is that without doubt the results are well worth the effort. I will simply present this paper as revised, asking that it be printed in due time, and leave with you this question, namely, whether without overloading the curriculum we can bring to the attention of our students an appreciation that there is a human side of engineering, as well as a material side.

Discussion.

Henry S. Jacoby: When this subject was presented to the engineering students in Cornell University, 155 men volunteered to devote two evenings a week to teaching foreigners in Ithaca. Many men were disappointed, since only twenty-nine groups were finally organized throughout the city. The experience of these teachers was really remarkable. They found that such personal contact was valuable to themselves. At the closing general session, one of the foreigners stated that as they saw these students coming to them night after night, through sleet or snow, rain or storm, teaching them without compensation, they felt that these men must be real friends. They could trust the college students, and could ask them about any life question; while they were afraid of other people who came to them in a different attitude. I need not take time to talk of the results at Yale Univeristy, where this kind of work was introduced.

Dr. C. R. Mann: This movement is not merely of tremendous benefit to the student of engineering, but also to the laborer who benefits from the instruction. This is one of the direct lines of contact by which the culture of the university—if Mr. Kent will pardon me—can be brought into contact with the life of the world. It is one line of attack on a big problem. I certainly hope it is going to be developed.

Professor E. F. Coddington: This Society may be interested to know that during the past year Mr. Rindge visited our Institution and asked if it would be possible for us to hold a human engineering congress at our Institution. We have that under consideration now. The prospects are that we will hold such a congress early this fall, perhaps about October, and will try to bring representatives from all over the country, who will be exponents of this movement. We are hoping for something very fine along this line. I can not assure you that this is going to take place, but we hope it will; and if it does take place we would be very happy to have this Association well represented.

LOUIS DUNCAN.

Louis Duncan was born in Washington, D. C., March 25, 1861, and died February 13, 1916, at Pelham Manor, New York. He was the third of four sons of the Rev. Thomas Duncan and Maria L. Morris Duncan.

Louis Duncan was educated in country schools in Maryland, Virginia and Tennessee until his entrance into the East Tennessee University. After one year's attendance there he was appointed to the U. S. Naval Academy from Kentucky, graduating twenty-third in his class in 1880. After two years' cruise in the Pacific Ocean he took his examination for Ensign, standing first in his class. He was then detailed to Johns Hopkins University to assist in the work of determining the absolute unit of electrical resistance for the U. S. government, receiving the degree of Ph.D. for this work in 1885 from the university.

He resigned from the Navy in 1886 to take the chair of electricity at Johns Hopkins where he continued until 1899. During these years he was continuously occupied in engineering work. He had charge of the construction of a number of electric roads in Baltimore; was consulting engineer for practically all the electric roads in Washington; and was engineer for the Baltimore & Ohio Company and installed the 100-ton electric locomotive which haul trains through the Baltimore tunnel. He resigned from Johns Hopkins in 1899 and became chief engineer and had charge of construction of the Third Avenue system in New York. In 1902 he was called to inaugurate the electrical engineering course at the Massachusetts Institute of Technology, remaining as head of the electrical engineering department until his resignation in 1904.

Louis Duncan contributed the articles on Electric Traction in the tenth and eleventh editions of the Encyclopedia Britannica and was the author of many scientific papers.

He was Lieut. Commander in the Maryland Naval Reserve and at the outbreak of the Spanish-American War was appointed Major of the First Battalion of the First Regiment of Volunteer Engineers.

ARTHUR EDWIN HAYNES.

Arthur Edwin Haynes, retired professor of engineering mathematics, died at his home March 12, 1915. Professor Haynes was obliged to give up his work in the University of Minnesota in 1911 on account of a stroke of paralysis which prevented his continuing his active connection with the University. To one who had been so active in University life, so ambitious for the advancement of his department, and who had so great a love for teaching, this proved a very great blow. Professor Haynes enjoyed, to an unusual degree, the genuine affection of those who were brought into close connection with him. He was not only an able teacher, but he took a human interest in those who were under his charge and was always interested in their welfare. He was also public spirited in his relations to the University community. The activity with which he was most closely connected, and which will be mentioned most often in connection with his name in years to come, is the securing of the student soldier memorial monument which stands on the university campus opposite the university armory.

Although Professor Haynes has not been actively connected with the university and on the campus daily during the past four years, his death will create a real vacancy in university circles, and there will be a large number of alumni and former students who will long cherish his memory as that of a very dear friend.

Professor Haynes was a member of the Society for the Promtion of Engineering Education since 1895.

J. W. MULDOWNEY.

Mr. J. Wm. Muldowney, instructor in charge of the Heating and Ventilating department at Franklin Union, Boston, died on September 15, 1916. Mr. Muldowney has lately been associated with J. P. Dwyer & Co., Boston, heating contractors, and with Hollis French & Allen Hubbard, Boston, heating engineers. Mr. Muldowney was also a member of the American Society of Heating and Ventilating Engineers, and has been in charge of the Franklin Union Heating and Ventilating department since its opening in 1908. He has been a member of the Society for the Promotion of Engineering Education since 1912.

FREDERIC H. ROBINSON.

Frederic H. Robinson was born at Wilmington, Delaware, on August 28, 1850, and died October, 1916. His early education was received in the Wilmington public schools, and later in the Wm. A. Reynolds Classical and Mathematical Institute, Wilmington, Delaware. After graduating he taught mathematics and English in the latter institute, in this way earning the money with which to pay his way through college. In 1875 he was graduated from the Polytechnic College of the State of Pennsylvania with the degree of B.C.E., winning the prize for the best graduating thesis. In 1883 he received from the same college the degree of C.E. Since his graduation he has occupied the following positions: Assistant Engineer, Pittsburgh Division of Pennsylvania Railroad; Assistant Professor and Professor of Mathematics, Polytechnic College; Draftsman Edgemoor Bridge Works; Assistant Engineer and Chief Engineer, Department of Engineering and Surveying, Wilmington, Delaware; Instructor in the Wilmington Drafting School; member of the firm of Canby and Robinson, Civil Engineers and Surveyors, Wilmington, Delaware; Assistant Engineer in the Corps of the Maryland Division of the P. B. and W. R. R. Since 1891 Professor of Civil Engineering, Delaware College, and since 1896 Secretary of the Faculty, he has written some verse, literary and scientific essays and the portion of a textbook on surveying. He was a member of the Society for the Promotion of Engineering Education since 1894.

GRIFFITH D. WALTERS.

Griffith D. Walters was born in Wales in 1884. He received the degree of B.S. in civil and irrigation engineering in the Colorado Agricultural College in 1911 and during the following year was assistant in irrigation investigations there under V. M. Cone. In 1913 he was engaged to take charge of the duty of water investigations for the Canadian government under F. H. Peters, commissioner of irrigation, and was at the time of his death chief agricultural engineer, Irrigation Branch, Department of the Interior. Mr. Walters died January 15, 1916. He was a member of the Society for the Promotion of Engineering Education since 1913.

Library
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INDEX.

PAGE.

Addresses of Welcome 18, 20

Administration, Report of Committee on 126

Alderman, E. A., Address of Welcome 18

  Discussion 70

Attendance at the Convention 7

Barker, Harry, Discussion 140, 280

Benton, J. R., Discussion 67, 270

Bishop, F. L., Discussion 154

Bowerman, M. R., Occupation and Distribution of Graduates from Engineering Colleges 304

Boyd, J. E., The Meaning of Integration in Calculus 319

  Discussion 195

Budget 9

Caldwell, F. C., Discussion 124, 172, 190, 215, 227

Chandler, E. F., Discussion 67, 219

Chatburn, G. R., Discussion 140, 151, 218

Civil Engineering, Report on 200

Coddington, E. F., Discussion 336

Committee on Committees vii

  Report of 43

Committees of the Society vii

Convention Picture ....

Cory, C. L., Discussion 69, 72, 138 216, 295, 297

Council, Members of v

Councils, Members of Previous xi

Crandall, C. L., Discussion 293

Crouch, C. H., Discussion 101

Cutter, W. P., Discussion 268

Deceased Members xiv

Dooley, C. R., Discussion 79, 81

Economics, Report of Committee on 198

Election to Membership 10

Electrical Engineering, Report of Committee on 221

Engineering Education and Co-operation Among Engineers, J. F. Hayford 316

English, Report of Committee on 177

Entrance Requirements, Report of Committee on 103
Faig, J. T., Discussion 270, 271, 276, 281
Final Program of the Twenty-fourth Annual Meeting xvi
FitzGerald, Desmond, Discussion 67
Fuller, A. H., Discussion 82, 132, 191
Gray, Alexander, Discussion 225
Greene, A. M., Jr., Discussion 72, 173, 197, 220, 281
Hayford, J. F., ENGINEERING EDUCATION AND CO-OPERATION AMONG ENGINEERS 316
Hedrick, E. R., Discussion 155, 172
Hedrick, Wm. A., Discussion 123
Higbee, F. G., Discussion 298
Howe, C. S., Discussion 82, 154
HUMAN SIDE OF ENGINEERING, THE, F. H. Newell 333
Institutional Committee, Report of 99
Jackson, D. C., Discussion,
    83, 122, 134, 137, 153, 154, 175, 176, 270, 271, 276, 290, 297
Jacoby, Henry S., Response to Address of Welcome 26
    Presidential Address 27
    Discussion 81, 173, 196, 197, 281, 335
Joint Committee on the Classification of Colleges, Report of 98
Joint Committee on Engineering Education, Report of 45
Jones, C. R., Discussion 218
Kent, Wm., Discussion 69, 97, 122, 138, 172, 173, 183
Key to Convention Picture ....
Lapham, J. S., Discussion 271
Leland, O. M., Discussion 171, 172, 208
Magruder, W. T., Discussion 141, 174, 175, 184, 273, 281
Mann, C. R., REPORT OF PROGRESS IN THE STUDY OF ENGINEERING EDUCATION 48
    Discussion 67, 71, 72, 77, 95, 97, 125, 175, 188, 336
Mathematics, Report of Committee on 143
Matheson, K. G., Discussion 137
Maurer, E. R., Discussion 149
MEANING OF INTEGRATION IN CALCULUS, THE, J. E. Boyd 319
Mechanical Engineering, Report of Committee on 210
Mechanics and Hydraulics, Report of Committee on 194
Miller, D. C., Discussion 171, 174
Mining Engineering, Report of Committee on 229
Minutes of the Twenty-fourth Annual Meeting 1
    Minutes of the Regular Sessions 1
    Minutes of Council Meetings 8
    Minutes of Meetings of Institutional Delegates 11
Moore, H. F., Discussion 295

Morris, C. C., A PLEA FOR THE FURTHER STUDY OF EFFICIENT METHODS IN THE ADMINISTRATION OF AN ENGINEERING COLLEGE. 311
McDaniel, A. B., SOME THOUGHTS ON ENGINEERING EDUCATION 328
New Members, see Election to Membership.
Newell, F. H., THE HUMAN SIDE OF ENGINEERING 333
Nomination Committee, Report of 4
Obituaries 337
OCCUPATION AND DISTRIBUTION OF GRADUATES FROM ENGINEERING COLLEGES, A. A. Potter and M. R. Bowerman 304
Officers 1916–17 v
Park, C. W., Discussion 192, 272, 277
Past Officers x
Past Presidents vi
Philbrick, H. S., Discussion 78, 123
Plant, L. C., Discussion 156
PLEA FOR THE FURTHER STUDY OF EFFICIENT METHODS IN THE ADMINISTRATION OF AN ENGINEERING COLLEGE, A, C. C. Morris 311
Potter, A. A., OCCUPATION AND DISTRIBUTION OF GRADUATES FROM ENGINEERING COLLEGES 304
  Discussion 95, 299
Presidential Address, Some Details in Engineering Education 27
RESEARCH AS AN ELEMENT OF THE GROWTH AND PROGRESS OF THE SCHOOL, P. F. Walker 284
Report of Officers, see Titles of Officers.
REPORT OF PROGRESS IN THE STUDY OF ENGINEERING EDUCATION, C. R. Mann 48
Reports of Committees, see Names of Committees.
Resolutions, Report of Committee on 6
Response to Address of Welcome 26
Rohrer, A. L., Discussion 84
Secretary's Report, 1915–16 14
Smith, C. A., Discussion 185
SOME DETAILS IN ENGINEERING EDUCATION, Henry S. Jacoby 27
SOME THOUGHTS ON ENGINEERING EDUCATION, A. B. McDaniel 328
Sperr, F. W., Discussion 67
Standardization of Technical Nomenclature, Report of Committee on the 241
Statistics, Report of Committee on 231
Teaching Physics to Students of Engineering, Report of Committee on 159
Thompson, F. F., Discussion 77, 220
Thornton, W. M., ADDRESS OF WELCOME ON BEHALF OF THE UNIVERSITY OF VIRGINIA 20
  Discussion 76, 135, 149
Treasurer's Report 1915–16 12

Waddell, J. A. L., Discussion 191
Walker, P. F., RESEARCH AS AN ELEMENT OF THE GROWTH AND PROGRESS OF THE SCHOOL 284
Discussion 151, 189, 197, 300
Whited, Willis, Discussion 152, 173
Wilson, J. F., Discussion 224
Wirick, C. M., Discussion 124
Withrow, J. R., Discussion 85
Wood, A. J., Discussion 217, 218